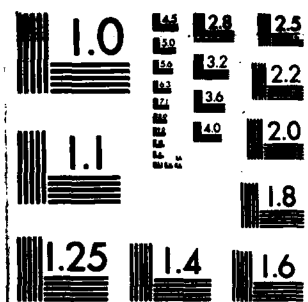
AD A156 532 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS MURPHY DAM (NH 00185)..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 81 1/2

UNCLASSIFIED F/G 13/13 NL



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

AD-A156 532

DISTRIBUTION STATEMENT A

Approved for public release
Distribution Unlimited

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING F
1. REPORT NUMBER NH 00185	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBE
4. TITLE (and Subtitle) Murphy Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD C INSPECTION REPORT
		6. PERFORMING ORG. REPORT NU
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE August 1981
		13. NUMBER OF PAGES 107
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this repo UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGR SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Pro
however, the official title of the program is: National Program for Inspect
Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Connecticut River Basin, and
Pittsburg New Hampshire.
~~Connecticut River~~
(fr p i)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam consists of an earth embankment dam with a side approach channel ov
spillway. It is large in size with a high hazard potential. The dam is in
condition . Although some deficiencies were noted, there was no evidence
of settlement, lateral movement or other signs of strucutral failure, or ot
conditions which would warrent urgent remedial action. Keywords include:

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDED

SEP 16 1981

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the Murphy Dam (NH-00185) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part.

Copies of this report has been forwarded to the Water Resources Board. Copies will be available to the public in thirty days.

I wish to thank you and the Water Resources Board for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

CONNECTICUT RIVER BASIN
PITTSBURG, NEW HAMPSHIRE

MURPHY DAM
NH 00185

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1981

NATIONAL DAM INSPECTION PROGRAM
PHASE I INVESTIGATION REPORT

Identification No.:	NH 00185
Name of Dam:	Murphy
Town:	Pittsburg
County and State:	Coos, New Hampshire
Stream:	Connecticut River
Date of Site Visit:	22 April 1981

BRIEF ASSESSMENT

to 1473

Murphy Dam consists of an earth embankment dam with a side approach channel overflow spillway. The crest length of the dam embankment is 2,200 ft. with a hydraulic height of 106 ft. Storage to the top of Murphy Dam (El. 1400) is estimated to be 131,375 acre-ft. Water is normally conveyed from the reservoir, Lake Francis, to the Connecticut River by the outlet works, which consists of a submerged upstream intake, gate house, 13-ft. diameter conduit, control house, stilling pool and discharge channel. Lake Francis, together with the First and Second Connecticut Lakes, is a storage reservoir for power generation along the Connecticut River.

Due to the potential loss of a more than a few lives and excessive economic loss, in the event the dam were to fail, Murphy Dam has been determined to have a "high" hazard potential classification in accordance with Corps of Engineers guidelines.

The dam is in good condition, based on a visual examination of the structure. Although some deficiences were noted, there was no evidence of settlement, lateral movement or other signs of structural failure, or other conditions which would warrant urgent remedial action.

Based on the "large" size and "high" hazard potential classifications, in accordance with Corps of Engineers guidelines, the test flood for this dam is the Probable Maximum Flood (PMF). With the water level at the top of dam, the spillway capacity without stanchion boards and flashboards is approximately 74,000 cfs, which is 121 percent of the test flood. The test flood outflow of 61,000 cfs (inflow of 81,300 cfs) can be passed with a freeboard of about 3 ft.

It is recommended that, within one year of this report, a registered professional engineer qualified in the design and construction of dams determine the character and the long term effect of the seepage along the downstream toe on the stability of the dam embankment, and establish procedures for monitoring of seepage at the overflow spillway, in order to arrive at necessary remedial measures, as outlined in Section 7.2. In addition, an evaluation of the potential impact of PMF overflow from the spillway discharge channel on the control house should be accomplished within two years after receipt of this report. Any necessary modifications resulting from the investigations, and remedial measures, including removal of vegetation from the spillway dikes and dam embankment, and repair of spalled and cracked concrete, as outlined in Section 7.3, should be implemented by the Owner within two years after receipt of this report. The Owner should also establish an emergency preparedness plan and downstream warning system for the dam site that compliments the state's existing disaster operations plan, "Link-Up", and should continue with the present program of annual technical inspections.

HALEY & ALDRICH, INC.
by:

THE STATE OF NEW HAMPSHIRE
PETER
REGISTERED
PROFESSIONAL ENGINEER

Peter L. LeCount
Vice President

This Phase I Inspection Report on Murphy Dam (NH00185) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

J W Finegan

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, MEMBER
Geotechmical Engineering Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of Chief of Engineers, Washington, DC 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm run-off), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential. Consideration of downstream flooding other than in the event of a dam failure is beyond the scope of this investigation.

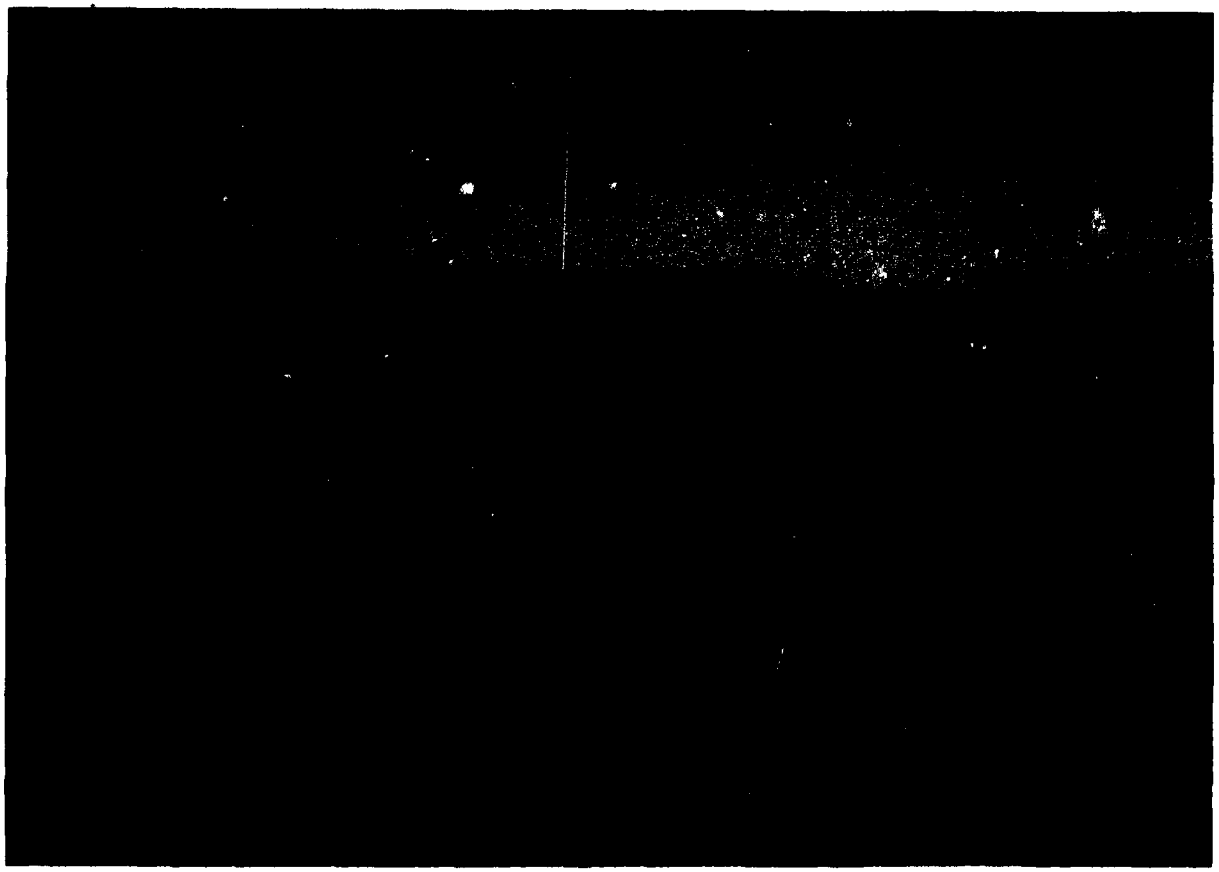
The Phase I Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be

needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

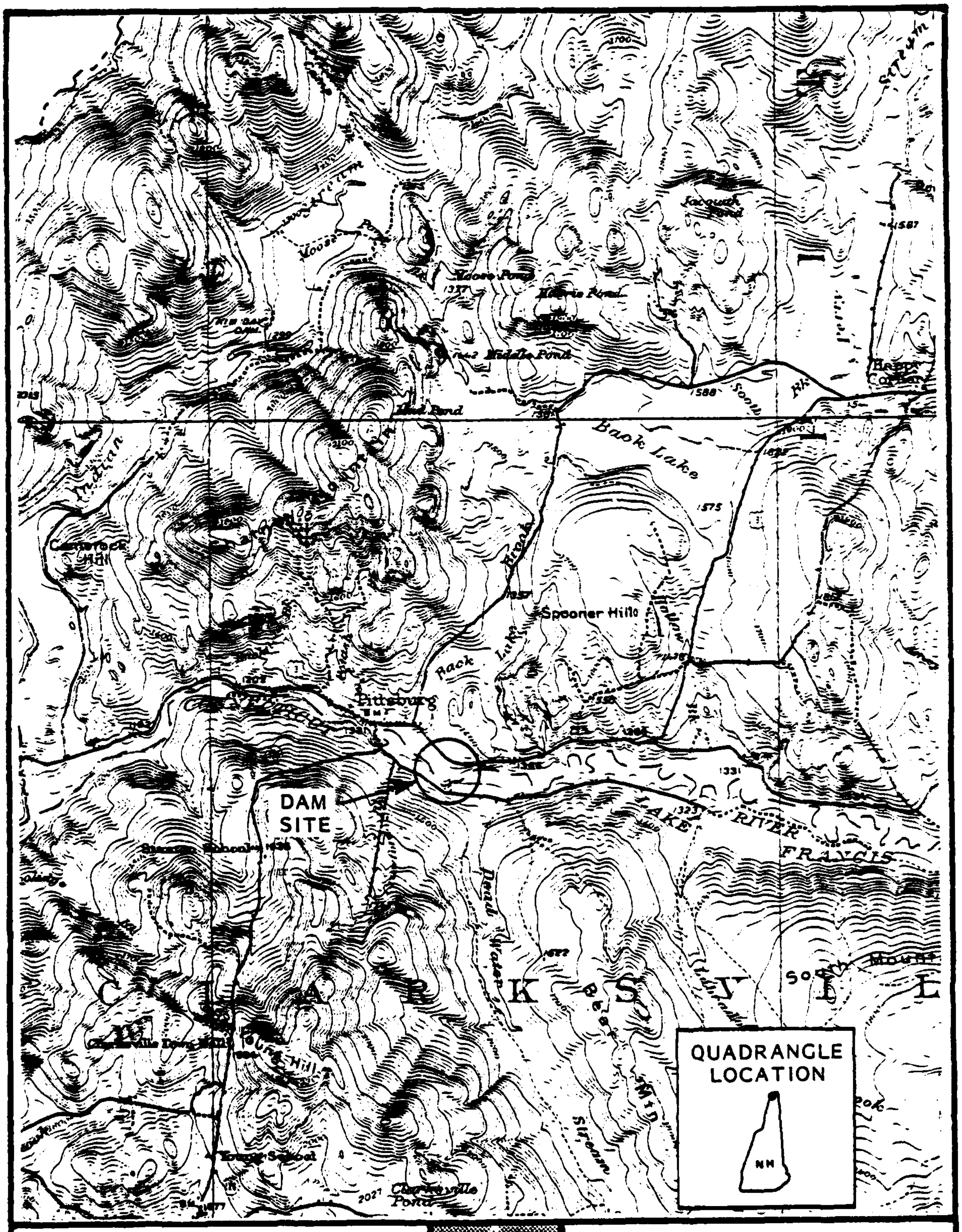
TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS



1. Overview of Murphy Dam showing downstream side



DAM: Murphy

IDENTIFICATION NO. NH 00185

LOCATION MAP

U.S.G.S. QUADRANGLE

INDIAN STREAM, NH-VT

APPROX. SCALE: 1" = 1 MILE

FILE NO. 4454 A57

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

MURPHY DAM
NH 00185

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England region.

Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the States of New Hampshire and Maine. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 31 October 1979 from Colonel William E. Hodgson, Jr., Corps of Engineers. Contract No. DACW33-80-C-0009 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hydrologic aspects of the Investigation.

b. Purpose of Inspection. The primary purposes of the National Dam Inspection Program are to:

1. Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

2. Encourage and prepare the states to intiate effective dam safety programs for non-Federal dams.

3. Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. The dam is located on the headwaters of the Connecticut River in the Town of Pittsburg, New Hampshire, as shown on the Location Map, page vii. The latitude and longitude of the dam site are N45°02.7' and W71° 22.9', respectively.

b. Description of Dam and Appurtenances. Murphy Dam consists of a zoned earth embankment dam with a side approach channel overflow spillway. The earth embankment dam has a straight alignment and is approximately 2200-ft. long with a hydraulic height of 106 ft. The spillway approach channel is located around the right, or north, end of the dam. From left to right training wall the spillway has an effective crest length of 208 ft. Low earth embankments are located immediately to the right and left of the spillway respectively designated west and east spillway dike. The east spillway dike and the dam adjoin giving the facility a continuous centerline crest length of about 3600 ft.

A roadway is located on the 20-ft. wide crest of the dam embankment. On the upstream side of the dam embankment from the toe to about El. 1385, the slope is 3 horizontal to 1 vertical (3H:1V); above El. 1385, the slope changes to 2H:1V up to the crest. Similarly, on the downstream side, the lower slope is 2.5H:1V and the upper part is 2H:1V. The transition of the downstream slope is not well defined, but is shown on design drawings to be at about El. 1370. Both the upstream and downstream toes are constructed of rock fill. A blanket of select pervious material underlies riprap on the upstream side. Large riprap, described as heavy derrick stone, covers the downstream slope.

Internally, the dam embankment has an impervious core with shoulders constructed of pervious material over and outside the impervious materials. The top of the impervious core is 20 ft. wide, and both the upstream and downstream sides have a slope of 2H:1V. Under about half of the embankment, starting at the left abutment, the core was designed to extend through the pervious overburden soils and into glacial til, or 10 ft. minimum depth below stripped natural ground, which ever was greater. Below the rest of

the embankment the core was keyed into sound bedrock. The embankment does not have an internal drainage system. However, seepage through the embankment is conveyed by the rock fill toe and, due to natural contours, collects in the general area of the original river bed.

The side approach channel is a somewhat irregular cut excavated in earth with riprap on portions of the side slopes. Founded on bedrock and constructed of concrete, the broad crested overflow spillway consists of four 37-ft. wide stop log bays* and one 60-ft. wide flashboard bay. The stop logs are 4-in. thick. Details of these bays are given in Section 1.3 and Section 5. A walkway bridge with concrete and steel truss spans crosses the spillway and is supported by 4-ft. wide piers that separate the individual stop logs and flashboard bays. A concrete training wall is located at the left upstream side of the spillway that provides protection for this end of the spillway.

The dikes at either side of the spillway each have a crest width of 20 ft. at El. 1400. Neither has an impervious core, but both are constructed of semi-pervious and impervious materials. Upstream and downstream slopes of both dikes are 2H:1V. Riprap is provided on the upstream sides of the dikes, which form the downstream end of the spillway approach channel. The crest and other portions of the dikes have grassed surfaces.

Flow over the spillway is conveyed by an 800-ft. long discharge channel to the Connecticut River. The upper 400 ft. of the channel is excavated in rock with concrete side walls, and the lower 400 ft. is excavated into earth with riprapped slopes.

Subsequent to the original design and construction of Murphy Dam, earth dikes were added along either side of the discharge channel upstream end. Referred to herein as the north (right) and south (left) spillway dikes, these dikes are each about 400 ft. long, and were constructed to retain high spillway flows. The crests of these dikes are 10 ft. wide and slope from approximately El. 1384, upstream, to El. 1380 downstream. These dikes are constructed of semi-pervious and impervious materials and have grassed crests and exterior slopes with riprap on their interior slopes. Both exterior and interior slopes are 2H:1V.

*Also called stanchion bays in the available information.

Water is normally conveyed to the Connecticut River by the outlet works. The outlet works consists of a concrete intake, gate house, two lengths of 13-ft. diameter conduit, control house, stilling pool and discharge channel.

The intake is located upstream of the left side of the dam embankment and has an excavated approach channel approximately 250 ft. long and 20 ft. wide at its bottom, with riprapped side slopes at 2H:1V. Both intake and approach channel are totally submerged by Lake Francis; the invert of the intake is at El. 1305.5. Water enters through two openings, each measuring 10 ft. by 20 ft., that are connected to a 253 ft. length of 13-ft. diameter conduit to the gate house. At the gate house the conduit flow is controlled by a Broome headgate raised (opened) and lowered (closed) by means of a gasoline engine and cable hoist. Located about 50 ft. upstream of the dam centerline, the gate house has a 6-ft. wide access bridge from the embankment crest upto the gate house operating floor, which is at El. 1404.

Between the gate house and control house, a distance of 587 ft., flow is conveyed beneath the dam by the second length of steel-plate-lined 13-ft. diameter conduit. At the control house the invert of the conduit is at El. 1302. The outlet control works consists of two 84-in. Dow Valves and one 30-in. Dow Valve that are activated by electric motors. Flow is measured by means of Venturi meters, one meter for the 30 in. valve and a large one for the two 84 in. valves. The three valves discharge into a 100-ft. long by 25 ft. wide stilling pool downstream from the control house.

Three stop log bays at the downstream end of the stilling pool control the pool water level at about El. 1311. One of the stop log bays is 15 ft. wide and the other two are 12.5 ft. wide. Discharge from the stilling pool flows about 200 ft. along a channel excavated in rock and enters the Connecticut River about 400 ft. upstream of the overflow spillway outlet.

C. Size Classification. The storage to the top of Murphy Dam is estimated to be 131,375 acre-ft., and the corresponding hydraulic height of the dam is approximately 106 ft. Storage of more than 50,000 acre-ft. and/or a height greater than 100 ft. classifies a dam in the "large" size category, according to the guidelines established by the Corps of Engineers.

d. Hazard Classification. Dam failure analysis computations in Appendix D which are based on "Guidance for Estimating Downstream Dam Failure Hydrographs" demonstrate why Murphy Dam has been determined as having a "high" hazard potential classification in accordance with Corps of Engineers guidelines. Channel water depths downstream of the dam prior to a dam failure would be approximately 20 ft. below the elevation of existing development. A failure of the Murphy Dam would result in water depths approximately 20 ft. above existing development and could destroy a minimum of 30 residential and commercial structures located immediately downstream of the dam in the Town of Pittsburg, New Hampshire. The potential loss of life would be more than a few. Furthermore, extensive damage would occur along several miles of the Connecticut River downstream of the dam.

e. Ownership. The name, address and phone number of the current owner are:

Water Resources Board
State of New Hampshire
37 Pleasant Street
Concord, NH 03301
Phone: (603) 271-3406

Mr. Vernon A. Knowlton is the Chief Engineer of the Water Resources Board.

f. Operator. Mr. David Chappell, Dam Operator, has been responsible for operation, maintenance and safety of the dam since 1974. His phone number is (603) 538-6530.

g. Purpose of Dam. Murphy Dam forms the reservoir of Lake Francis. Lake Francis, together with the First and Second Connecticut Lakes, is a storage reservoir for power generation along the Connecticut River. In addition, Murphy Dam provides some flood storage capacity.

h. Design and Construction History. Design and construction records that are available through the Water Resurces Board of the State of New Hampshire, document when and how the dam was built.

i. Normal Operational Procedures. Maintenance of the Dam is performed on a routine schedule. The operator who is permanently assigned to the facility has responsibility for the operation of the conduit gate controls and

spillway stop logs and flashboards on an as-needed basis. During dry weather periods, normal operation is to release flows through the outlet works on demand by the downstream power generating facilities. During periods of high reservoir inflows, there are formal operating procedures to be followed by the Dam Operator in the event that communication with advisors is not possible. A copy of the written procedures is contained in Appendix B.

1.3 Pertinent Data

All dimensions and elevations reported herein are from project records and are based on National Geodetic Vertical Datum (NGVD) of 1929.

a. Drainage Area. The drainage area tributary to the dam site is 174 sq. mi., consisting of two major watersheds: Perry Stream having 78 sq. mi. of uncontrolled drainage area and 96 sq. mi. which is controlled by the First and Second Connecticut Lakes. All of the 174 sq. mi. drainage area is heavily forested and essentially undeveloped.

b. Discharge At Dam Site.

1. Outlet works.............	Maximum controlled discharge - 2,000 cfs
2. Maximum known flood at dam site.................	Maximum recorded reservoir stage El. 1386.2 on 25 May 1977
3. Spillway capacity at top of dam.............. (without stop logs and flashboards)	74,000 cfs at El. 1400.0
4. Spillway capacity at test flood pool elevation................ (without stop logs and flashboards)	61,000 cfs at El. 1397.0
5. Gated spillway capacity at normal pool elevation.....................	Not applicable
6. Gated spillway capacity at test flood pool elevation................	Not applicable
7. Total spillway capacity at test flood pool elevation................	61,000 cfs at El. 1397.0

8. Total project discharge at top of dam............ 76,000 cfs at El. 1400.0

9. Total project discharge at test flood pool elevation................ 63,000 cfs at El. 1397.0

c. Elevation. (ft. above NGVD)

1. Streambed at centerline of dam..................	1294.0
2. Maximum tailwater.......	Design tailwater unknown.
3. Upstream portal invert diversion tunnel........	1305.5
4. Maximum normal pool......	1378.0
5. Full flood control pool.	Not applicable
6. Spillway crest (without stop logs and flashboards)............	One 37-ft. wide bay at El. 1370. Three 37-ft. wide bays at El. 1375.0 One 60-ft. wide bay at El. 1383.0
(with stanchion boards and flashboards)........	El. 1385.0 on 37-ft. wide bays El. 1386.0 on 60-ft. wide bay
7. Discharge surcharge - original design.........	1390.3
8. Top of dam..............	1400.0
9. Test flood surcharge....	1397.0

d. Length of Reservoir. (mi. estimated)

1. Maximum normal pool.....................	5.35
2. Flood control pool.....................	Not applicable
3. Spillway crest..........	5.3
4. Top of dam..............	5.5
5. Test flood pool.........	5.4

e. Storage.(acre-feet)

1. Maximum normal pool.....	86,500 at El. 1378.0
2. Flood control pool......	Not applicable
3. Spillway Crest..........	71,180 at El. 1370.0
4. Top of dam..............	131,375 at El. 1400.0
5. Test flood pool.........	125,000 at El. 1397.0

f. Reservoir Surface. (acres)

1. Maximum normal pool.....	1,895 at El. 1378.0
2. Flood control pool......	Not applicable
3. Spillway crest..........	1,766 at El. 1370.0
4. Top of dam..............	2,240 at El.1400.0
5. Test flood pool.........	2,210 at El. 1397.0

g. Dam Embankment.

1. Type....................	Rolled earth fill
2. Crest length............	2200 ft.
3. Height..................	100 ft.
4. Top width...............	20 ft.
5. Side slopes.............	3H:1V to 2H:1V U/S 2.5H:1V to 2H:1V D/S
6. Zoning..................	Impervious core with U/S and D/S shoulders of semi-pervious and pervious materials
7. Impervious core.........	Compacted impervious fill
8. Cutoff..................	Core carried up to 10 ft. below natural stripped ground surface or keyed into bedrock
9. Grout curtain...........	Contract provided for drilling and grouting where core is keyed and founded on bedrock

Spillway Dike Embankments

	East	West
1. Type....................	Rolled earth fill	
2. Crest length............	410 ft.	530 ft.
3. Height..................	10 ft.	17 ft.
4. Top width...............	20 ft.	20 ft.
5. Side slopes.............	2H:1V both U/S and D/S	

Discharge Channel Dike Embankments

	North	South
1. Type....................	Rolled earth fill	
2. Crest length............	400 ft.	400 ft.
3. Height.(estimated)......	14 ft.	16 ft.
4. Top width...............	10 ft.	10 ft.
5. Side slopes.............	2H:1V both U/S and D/S	

h. Diversion and Regulating Tunnel. Not applicable

i. Spillway

1. Type................. Broad crested concrete overflow

2. Length of weir......

Bay No.	Width (ft.)
1	37*
2	37*
3	37*
4	37*
5	60**
Effective crest length	208
4-4 ft. wide concrete piers	16
Total length of weir	224

3. Crest elevation.....

Bay No.	Elev.
1	1370.0*
2	1375.0*
3	1375.0*
4	1375.0*
5	1383.0**

*Stop logs (also called stanchion boards)
**Flashboards

4. Gates............... None

5. U/S channel......... Excavated from earth overburden with riprap on side slopes

6. D/S channel......... Upper portion excavated from rock with concrete side walls. Earth dikes parallel upper portion at each side of channel. Lower portion excavated from earth.

7. General............. Stop logs are manually released. Half of flashboards (30 ft.) designed to release automatically with upstream water level at El. 1387.6, other half designed to release at El. 1388.1.

j. Regulating Outlet

1. Description...........	13-ft. diameter penstock 975 ft. long, with 13 ft. x 13 ft. Broome Gate U/S and two 84-in. diameter and one 30-in. dia. butterfly valves D/S; 30 in. valve is by-pass for low flow
2. Size..................	Two 84 in. valves and one 30 in. valve
3. Invert................	84 in. valves at invert El. 1301.50 30 in. valve at invert El. 1297.5
4. Control mechanism......	Two 84 in. Dow valves electric motor operated with standby gasoline engine. 30 in. Dow valve manually operated. All control mechanisms at El. 1322 in control house

SECTION 2 - ENGINEERING DATA

2.1 Design Data

The dam and appurtenant structures were designed between 1937 and 1939 by the firm of Charles T. Main, Inc., Engineers, of Boston, Massachusetts. Documentation of the project design, consisting of some originals and mostly copies of construction drawings and geologic reports, is available through the offices of the Water Resources Board in Concord, New Hampshire. However, no design computations were located or are known to exist.

2.2 Construction Data

The dam was constructed during 1938 through 1940. Records of the construction of the dam are kept at the dam site in the control house. These records are in the form of field plans, daily reports, progress photographs, monthly estimates and weekly reports on construction, soils laboratory test records and concrete pour records.

2.3 Operation Data

Formal procedures exist for activating the controls and outlets of Murphy Dam under emergency conditions and are posted in the control house. The Dam Operator fills out an Operation Record form daily (see Appendix B) and maintains a written log of activities at the dam site. Operation of the dam is coordinated with the needs of the both the New England Electric System and Public Service Company of New Hampshire.

2.4 Evaluation of Data

a. Availability. A list of the engineering data available for use in preparing this report is included on page B-1. Selected documents from the listing are also included in Appendix B.

b. <u>Adequacy</u>. There was a considerable amount of engineering data available to aid in the evaluation of Murphy Dam. A review of these data in combination with visual examination, consideration of past performance and application of engineering judgement, was adequate for the purposes of a Phase I assessment.

c. <u>Validity</u>. The information contained in the engineering data may generally be considered valid. However, details on the drawings are shown as designed and some differ from those actually built. Heavy derrick stone was used on the downstream slope of the dam in lieu of riprap, and the north and south spillway dikes were added after the dam was constructed. The spillway boarding system and left abutment wall have also been changed from the original design and construction shown on the drawings.

SECTION 3 - VISUAL EXAMINATION

3.1 Findings

a. General. The Phase I visual examination of Murphy Dam was conducted on 22 April 1981. The upstream water surface was at about El. 1370.5. The Operator was controlling discharge at about 15 cfs and raising the level of the reservoir.

In general, the project was found to be in good condition. Several deficiencies which require correction were noted. The Operator demonstrated the operability of outlets and controls and cooperated in all aspects of the site inspection.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C. A "Site Plan Sketch", page C-1, shows the direction of view for each photograph.

b. Dam. At the dam embankment crest, from the left abutment to about the gate house, the gravel surface had a thin covering of vegetation indicating that this portion of the roadway is not frequently travelled. Alignment of the crest was good to excellent, and visually, in agreement with the design drawings. There were small local depressions, but no major rutting or erosion, along the crest and at the abutments. Unpaved service roadways at either end of the dam were in satisfactory condition.

At the upstream side of the dam, the transition of the slope from 3H:1V to 2H:1V at about El. 1385 was readily distinguishable, Photo No. 3. The gate house and associated foot bridge were in a well maintained condition and showed no indications of structural distress where they adjoin the embankment, Photo No. 4. No large tree growth was present on the embankment slopes but wooded areas were located close to both the abutments and the downstream toe, Photo No. 5. Grass, brush, weeds, moss and small (less than 1 in. diameter) trees and tree stumps (up to 3 in. in diameter) between the stone protection on the upstream and downstream sides obscured the slopes, Photos No. 2 and No. 6. This ground cover may have hidden indications of local sloughing, erosion, slope failures or animal burrows. The rock protection also makes both slopes quite jagged and uneven, particularly on the downstream side, Photo No. 6. This unevenness appeared to be caused by the large and variable size of the

heavy derrick stone. In addition, there may have been irregular placement during the original construction. The transition of the downstream slope from 2.5H:1V to 2H:1V at about El. 1370 had a concave appearance that was not as visible as the transition of the upstream slope.

During the construction of the dam, seeded loam was placed directly over the lower end of the downstream rock fill toe and has formed a blanket of sod over this section of the dam. A number of local depressions and sink holes have developed over the rock fill along the toe from either foot traffic, erosion due to local runoff, seasonal frost action or a combination of these factors. The largest sink hole along the downstream toe was located near the middle of the dam and extended approximately 7 ft. laterally under the sod, Photo No. 8.

A long shallow swale located downstream of the dam, skewed with respect to the alignment of the dam and corresponding to the location of the outlet works conduit, was soft with ponded water from local snow melt runoff, Photo No. 7. It was reported in the available information that this was a long-standing condition, occurring in the spring, and that the area dries in the summer.

There were signs of beaver activity in a wooded area immediately downstream of where the dam crosses the previous alignment of the Connecticut River. Fallen trees were prevalent and what looked like an abandoned beaver lodge and beaver dam with an associated pond were located within a spoil area from the construction of the facility. Flow tributary to the pond originates primarily as runoff from the hillside left and downstream of the dam and as seepage conveyed by the rock fill toe. On the day of the site inspection there was runoff due to snow melt. The Operator reported that during the summer water can be heard flowing beneath a portion of the downstream slope protection; however, this flow could not be detected on the day of the site visit.

A thin accumulation of silt and sand approximately 3 ft. by 5 ft. in area has formed at the upstream end of the beaver pond, Photo No. 10. Most of the deposited material was apparently from the area of an unpaved access road downstream of the left dam abutment. However, some of the material appeared to have been coming from the direction of the rock fill toe of the dam. A report by Chas. T. Main, Inc. dated 1977 noted that there was flow along about 300 ft. of the rock fill toe and that minor seepage was

emerging along the downstream toe in the area of the old river bed, but did not indicate an accumulation of silt or sand in the area of the beaver pond. From the reported information it is believed that the condition is long-standing, but the significance of the silt and sand and what effects the seepage may have on the stability of the dam have not been determined.

A single 3-in. ID steel pipe, described as an observation riser and located within the Connecticut River bed immediately downstream of the embankment, was flowing at the time of the inspection, indicating an artesian condition in underlying soils, Photo No. 9. The lower invert of the pipe and whether the pipe has any perforations are unknown. Flow from the pipe has been measured by the Operator; however, the outlet can become submerged by the beaver pond, making direct measurements of flow impossible. No boils or springs were observed at the downstream toe or in the area of the riser pipe.

c. Appurtenant Structures. The broad crested overflow spillway was in generally good condition, Photo No. 15. The bridge seats in the concrete piers and right spillway abutment were spalled, as was the downstream portion of the flashboard bay apron. The downstream face of the concrete portion of the walkway bridge was also spalled, although in general both the steel truss and concrete spans of the bridge were in good condition. The flashboard and stop log systems were also in good condition.

The spillway approach and discharge channels, Photos No. 18 and No. 19, had some vegetation in the form of brush present. There were cracks in the panels of concrete rock facing in the left spillway discharge channel wall, Photo No. 21. There was an apparent seepage condition at the toe of the spillway apron adjacent to to the left wall, Photo No. 20, as evidenced by greater flow downstream from the apron than over the apron. The flow appeared clear. These deficiencies were considered to be minor and therefore the general condition of the spillway approach and discharge channels was good.

The four low earth embankments, spillway dikes, were all in good condition overall. However, from the Operator's records it is apparent that the east and west dikes, Photos No. 16 and No. 17, have not had to retain a full reservoir. Further, it appears that the north and south dikes, along the spillway discharge channel, have never been required to retain high spillway flows.

The crests of the east and west spillway dikes were level, had well mowed grass surfaces and uniform slopes. No evidence of significant erosion or sloughing was apparent; however, at several locations on the west dike there were small local displacements, possibly due to frost action or tree removal operations. Numerous stumps were located on the upstream side of the west dike as were several, cut nearly flush to the ground surface, on the downstream side.

On the upstream side of the east spillway dike there was a thick development of trees. The root systems of this mature tree growth traverse the crest of the dike. A rock outcrop at the right end of the east spillway dike adjacent to the overflow spillway also had many mature trees growing across it.

The gate house was also in good condition. The dam operator was present during the inspection and the Broome head gate was operated with no deficiencies noted, as was the head gate by-pass valve. The concrete access bridge spanning from the gate house to the dam crest was in good condition. The alignment and general condition of the concrete abutment upon which the bridge is seated at the dam crest were good.

The control house located downstream of the dam was in good condition, Photo No. 11. The two electric motor operated 84-in. Dow butterfly valves were opened to drain the outlet conduit and permit its inspection, Photo No. 14. The low flow 30-in. Dow valve was operated manually. An emergency stand-by gasoline engine is available for operation of the 84-in. Dow valves. During the control house inspection, this engine was started and kept running for a time, demonstrating its operable condition.

A walk-thru inspection of the 13-ft. diameter buried conduit revealed no significant deficiencies. The steel plate lining was observed to be sound with only minor corrosive action noted. The head gate at the upstream end of the conduit was leaking to a moderate extent at the lower right corner. The two 84 in. butterfly valves at the downstream end were observed to be in good condition as was the 13-ft. by 8-ft. Venturi meter. The 30 in. butterfly valve was submerged.

The outlet works stilling pool, Photos No.12, was in generally good condition with minor spalling and some seepage noted at the upstream vertical construction joints. Cracks were observed in the basin headwall above the conduit outlet valves. One of the cracks appeared to define a fairly large spall area. Some seepage was also observed at a horizontal construction joint in this wall and/or from a line of weep holes located directly above the joint. Despite these conditions, the wall is considered to be structurally adequate. Observation of the three bay stop log facility at the downstream end of the stilling pool showed the concrete piers, the stoplogs and the 30-in. by-pass gate to be in good condition. The by-pass gate was operated manually to drain the pool during the site visit, Photo No. 13.

d. Reservoir Area. Lake Francis is approximately 5.5 mi. long and has a maximum width of about 1.4 mi. In general, the reservoir shoreline consists of undeveloped, moderately sloped wooded banks. The formation of the reservoir required the abandonment/relocation of two roadways and approximately 20 structures. The Connecticut River extends approximately 2 mi. upstream of Lake Francis to the outlet from the First Connecticut Lake.

e. Downstream Channel. The Connecticut River flows from the dam through the states of New Hampshire, Vermont, Massachusetts, and Connecticut. The outlet works discharge channel joins the original Connecticut River bed about 600 ft. downstream of the toe of the dam. The spillway discharge channel joins the Connecticut River approximately 400 ft. further downstream. The Town of Pittsburgh, New Hampshire is located on the right bank of the river approximately 3,000 ft. downstream of the dam, Photo No. 22.

3.2 Evaluation

Based on the visual examination conducted on 22 April 1981, Murphy Dam is considered to be in good condition. No condition was observed that would immediately affect the safety of the facility. The sink hole and shallow wet swale downstream of the dam embankment are not considered to be deficiencies in the dam. The seepage and possible soil erosion at the downstream toe of the dam embankment in the area of the beaver pond require further monitoring and evaluation. The seepage observed downstream of the spillway at the end of the portion of the spillway apron adjacent to

the left training wall also warrants monitoring. The left training wall of the spillway discharge channel, the bridge seats in the concrete piers at the spillway crest, and the outlet works stilling pool headwall, need attention to prevent further deterioration. Remedial measures outlined in Section 7.3 should be implemented to correct the noted deficiencies.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. There are formal procedures for the operation of Murphy Dam. Entitled, Operation Procedure for Pittsburg Reservoir During Period of High Inflow to be Followed by Operator if Communication with Advisors is not Possible, the procedures are conspicuously posted in the control house. Flashboards and stop logs are maintained on the spillway weir year round. The conduit head gate and outlet works butterfly valves are operated as-needed to withdraw water as required by the downstream users.

b. Description of any Warning System in Effect. There is no specific warning system or emergency action plan in effect for Murphy Dam. However, the Owner is within the framework of the operations plan "Link Up", an interagency plan in the state of New Hampshire for natural and man-made disaster operations. This plan establishes the procedure for notifying and calling upon the resources of other state agencies in times of emergency.

4.2 Maintenance Procedures

a. General. Available references indicate that the Murphy Dam is inspected annually under the auspices of the New Hampshire Water Resources Board in cooperation with the project's water users. It is further indicated that an additional program consisting of inspections at five year intervals by an outside consultant also exists. The written report resulting from the first of the five year interval inspections was furnished by the Owner. The report is dated November 1977, and includes a summary of an on-site inspection of the facility, a PMF hydrological study of the facilities, and stability analyses of the structure.

b. Operating Facilities. The spillway appeared to be well maintained and free of debris as did the outlet works stilling pool and discharge channel. The head gate control tower and outlet works control house were also well maintained and the functional operation of all gates in the outlet works was demonstrated. A formal written maintenance procedure entitled, Pittsburg Reservoir Maintenance Procedure Broome Gate and Hoist, was posted in a fully viewable location inside the head gate control tower.

4.3 Evaluation

Formal operation and maintenance procedures are in effect for the project. Remedial work at the facility is based on conditions observed during the annual technical inspections. The annual technical inspections should be continued.

Since a failure of the dam would cause loss of life, and extensive property damage downstream, a detailed emergency action plan and warning system should be established for Murphy Dam to compliment the existing operations plan "Link-Up".

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

Lake Francis, and the First and Second Connecticut Lakes, are storage reservoirs for power generation along the Connecticut River by the New England Electric System and the Public Service Company of New Hampshire. The 174 sq. mi. drainage abea tributary to Lake Francis consists of two major watersheds: Perry Stream having 78 sq. mi. of uncontrolled drainage area and 96 sq. mi. which is controlled by the First and Second Connecticut Lakes. Murphy Dam, which impounds Lake Francis, is a 2,200 ft. long by 106 ft. high earth embankment structure with a gated outlet conduit for the normal release of flow and a side approach overflow spillway with flashboards and stop logs* for flood discharges.

The outlet works consists of a 975 ft. long, 13 ft. diameter conduit having the following appurtenant features: Upstream intake structure with trash rack; upstream gate house for 13-ft. by 13-ft. Broome head gate; and downstream control house and stilling pool.

Normal outlet works operation for the release of flows for downstream power generation is regulated by two 84 in. butterfly valves and gaged by a 13 ft. by 8 ft. Venturi meter. When no discharge is required by the downstream power plants, the 13 ft. by 13 ft. Broome head gate is kept open, the two 84 in. butterfly valves are closed, and a minimum fish flow of 15 cfs is released by a 42 in. by 30 in. by-pass pipe and gaged by a 42 in. by 28 in. Venturi meter.

The side approach channel overflow spillway consists of five bays having a total weir length of 224 ft. and includes earthen dikes at El. 1400 at both abutments as well as a concrete bulkhead wall at the spillway left abutment at El. 1395.0. The five spillway bays have the following geometry:

Bay No.	Width (ft.)	Crest Elev.	Board Elev.
1	37	1370.0	1385.0
2	37	1375.0	1385.0
3	37	1375.0	1385.0
4	37	1375.0	1385.0
5	60	1383.0	1386.0

*Also called stanchion boards in the available information.

Bay Nos. 1, 2, 3 and 4 incorporate stop logs with manual release mechanisms and Bay No. 5 incorporates self-releasing flashboards. Spillway discharges are conveyed by an 800-ft. long discharge channel to the Connecticut River.

5.2 Design Data

The spillway was originally designed to discharge 36,000 cfs at reservoir (Lake Francis) El. 1390.3. At this stage there would be 9.7 ft. freeboard at the main dam and spillway dikes and 2.7 ft. at the spillway left concrete retaining wall as originally constructed.

Hydrologic analysis, conducted by Chas. T. Main, Inc. in 1958 (see Appendix B), for an "extreme flood" (ie: 18 in. of rainfall in 30 hours resulting in 15 in. of total run-off) determined that the peak inflow would be 72,000 cfs, peak outflow 51,300 cfs and reservoir El. 1394.1. At this stage, the spillway left abutment concrete wall would be overtopped by 1.1 ft. as originally constructed. Consequently, this wall was raised two feet to El. 1395.0.

5.3 Experience Data

Maximum and minimum recorded reservoir levels occurred on 25 May 1977 at El. 1386.2 and on 18 March 1977 at El. 1324.9, respectively. The level at the time of inspection on 22 April 1981 was El. 1370.5. During the Phase I inspection, the 13 ft. diameter outlet work conduit and stilling pool were dewatered to faciliate their inspection. The operating procedures required to accomplish this were as follows:

1. Initially, the 13 ft. sq. head gate was open, the two 84 in. butterfly valves were closed, the stilling pool was full to El. 1311.0, and the 30 in. by-pass butterfly was partially open to release 15 cfs for fish flow in the Connecticut River.

2. The 30 in. butterfly valve was manually closed at the control house.

3. The 13 ft. square head gate at the gate house was closed using the gasoline-driven motor.

4. The head gate by-pass gate was manually opened at the gate house.

5. The two 84 in. butterfly valves were opened using the electric motors at the control house. The stand-by gasoline motor was also started to demonstrate its operability.

6. The head gate by-pass was closed at the gate house and cinders were placed at the upstream face of the 13 ft. square head gate to minimize leakage and facilitate its inspection.

7. The 30 in. stilling pool drain gate was opened and wedges were driven between stoplogs to accelerate the dewatering of the pool.

8. The 30 in. butterfly valve was opened at the control house so as to dewater the low point in the 13 ft. diameter conduit immediately upstream of the 13 ft. by 8 ft. Venturi meter.

5.4 Test Flood Analysis

Based on the Corps of Engineers Guidelines, the recommended test flood for the size "large" and hazard potential "high" is the PMF (Probable Maximum Flood). Application of the Corps of Engineers Guideline Curves for estimating peak PMF inflows is inappropriate due to the attenuating effects of the upstream storage at the First and Second Connecticut Lakes.

PMF analysis performed in 1977 by the design engineer developed unit hydrographs for the two major contributary watersheds based on a geomorphologically similar watershed. The PMF outflow from the First Connecticut Lake was determined to be 34,200 cfs (inflow = 53,690 cfs) which, when combined with the Perry Stream PMF hydrograph, resulted in a Lake Francis inflow of 81,300 cfs.

The Lake Francis routed PMF outflow peak was determined to be 61,000 cfs at a reservoir stage of El. 1397.0. At this stage, there would be 3 ft. of freeboard on the dam and east and west spillway dikes; the spillway is therefore considered adequate. However, at reservoir El. 1397.0 the spillway left abutment concrete retaining wall would be overtopped by 2 ft. of water. Prior hydrologic analysis had indicated that this non-overflow retaining wall would be overtopped by an "extreme flood" (reservoir El. 1395.0 and discharge of 51,300 cfs) and consequently an additional 2 ft. had been added to the top of the wall bringing it to its present elevation of 1395.0.

Prior hydraulic analysis of the spillway discharge channel by the design engineer also determined that a discharge of 49,300 cfs would overtop the channel banks beginning about 300 ft. downstream of the spillway weir. While no detailed backwater analysis has been performed for a PMF discharge of 61,000 cfs, it is apparent that it would overtop the discharge channel nearer to the spillway weir than 300 ft. While this overflow, combined with the 2 ft. overtopping of the spillway left abutment retaining wall, might not adversely impact on the dam embankment, it could cause serious damage to the control house as the overflow would be directed towards it. The ground floor level of this structure is at El. 1333.0 and the gate motor operators are at floor El. 1322.0. Tailwater analysis by the design engineer determined that the Connecticut River would flood to El. 1330.0 in the vicinity of the control house during the PMF outflow.

5.5 Dam Failure Analysis

Based on the Corps of Engineers guidelines for estimating dam failure hydrographs and assuming that a failure would occur along 40 percent of the mid-height length of the dam (480-ft. breech width), the peak failure outflow is estimated to be about 843,000 cfs. A flood wave of this magnitude would inundate the Town of Pittsburg, which is located about 3,000 ft. downstream of the dam, by about 20 ft. of water. Prior to a dam failure, channel water depths would be about 20 ft. below the elevation of existing development. As a result of a dam failure, a minimum of 30 residential and commercial structures would be destroyed. The Connecticut River is located in a steep valley downstream of the dam with no significant overbank flood plain. Consequently, the flood wave would continue for several miles downstream at a depth of 50 to 70 ft. above the normal channel water surface elevation.

The potential loss of life resulting from a dam failure would be at least several persons and the economic loss, excessive. The dam is accordingly classified in the "high" hazard potential.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

There was no visual evidence of settlement, lateral movement or other signs of structural instability in the dam embankment, overflow spillway and associated dikes, gate house or outlet works facilities during the site inspection. All portions of the project appeared to be performing satisfactorily under present conditions. Based on the visual examination conducted on 22 April 1981, no reason was found to question structural stability of the dam.

6.2 Design and Consruction Data

Construction drawings and documentation of the construction operations were located. From a review of the information it appears that the construction operations were closely monitored to insure compliance with the intended design. Records were made of the pertinent aspects of the construction, including but not limited to soil and rock types encountered, tests of geotechnical properties, concrete pour data and visual observations.

As part of the inspection of the facility in 1977 by Chas. T. Main, Inc., stability analyses were conducted for all important water retaining structures and the intake gate tower for a full reservoir condition, a full reservoir with both seismic and ice conditions, a rapid drawdown condition, a rapid drawdown with seismic condition, and a probable maximum flood condition. Based on the review of the available information, the earth embankment dam, overflow spillway and appurtenant structures are considered to be stable.

6.3 Post-Construction Changes

Written documents recommending changes to the spillway facility were located. A report prepared by Chas. T. Main, Inc. in 1958 and forwarded to the New Hampshire Water Resources Board recommended removal of a failing flashboard system originally installed in conjunction with stop logs

in four of the spillway bays. In addition, it was recommended that the height of the left upstream concrete spillway abutment wall be increased by two feet. Also located w a plan, dated September 1942, which details the original construction of the boarding system in the spillway bays. No formal written documentation confirming implementation of the recommended changes was located. However, visual observation during the site inspection on 22 April 1981, indicated a stop log system without flashboards in four of the spillway bays, while the fifth bay boarding system consisted entirely of flashboards. Furthermore, an additio of two feet in height to the spillway left abutment concret retaining wall was apparent.

6.4 Seismic Stability

As described in Section 6.2 above, seismic stability analyses have been performed for the major water retaining structures and the intake gate house, considering both full reservoir and rapid drawdown conditions. The analyses indicate the structure would be stable under the assumed conditions. Murphy Dam is located in a Seismic Zone 2, and in accordance with Corps of Engineers' guidelines does not warrant further seismic analysis at this time.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination of Murphy Dam revealed that the dam and appurtenant structures were in good condition. Although there were no signs of impending structural failure or other conditions which would warrant urgent remedial action, several deficiencies were noted.

Based on the results of hydrologic computations by the design engineer, included in Appendix D and summarized in Section 5, the spillway is capable of passing the test flood, which for this structure is the PMF, without overtopping the dam. With the water level at the top of the dam, the ungated spillway capacity is approximately 74,000 cfs. The test flood outflow of 61,000 cfs (inflow of 81,300 cfs) could be passed with a freeboard of 3 ft. and an unused surcharge-storage of approximately 6,300 acre-ft. remaining.

b. Adequacy of Information. This evaluation of the dam is based primarily on visual examination, hydraulic and hydrologic computations by others, consideration of past performance and application of engineering judgement. Generally, the information available or obtained was adequate for the purposes of a Phase I assessment.

c. Urgency. Recommended additional investigations 1, 3 and 4, outlined in Section 7.2, should be undertaken by the Owner and completed within one year after receipt of this report. The recommended remedial measures outlined Section 7.3 and additional investigation 2 should be accomplished within two years after receipt of this report.

7.2 Recommendations

It is recommended that a registered professional engineer qualified in the design and construction of dams undertake the following investigations:

1. Determine the extent and character of seepage flow beneath the downstream slope protection and at the downstream toe of the dam embankment. The long term effect of the seepage on the stability of the dam should be evaluated, as well as what corrective measures are warranted.

2. Evaluate the potential impact of PMF overflow at both the spillway left abutment retaining wall and south spillway dike on the control house.

3. Clear away the leaves and establish a program to make periodic observations of the seepage condition at the left side of the overflow spillway apron under various reservoir water levels, noting carefully the extent and location of seepage. Based upon the results of the monitoring program determine the repairs warranted to correct the condition.

4. Delineate the areas where brush and tree growth should not be permitted. Establish procedures for the removal of brush, tree, stumps and their associated root systems. These procedures should consider the type of material used to backfill voids, the removal and replacement of riprap protection on affected upstream slopes, and providing and maintaining a well-developed growth of vegetation on crests and downstream areas at completion of the work.

The Owner should then implement corrective measures on the basis of these engineering evaluations.

7.3 Remedial Measures

Although the dam and appurtenant structures are generally in good condition, it is considered important that the following items be accomplished by the Owner:

a. Operation and Maintenance Procedures. The following should be undertaken by the New Hampshire Water Resources Board:

1. In areas where brush, trees and stumps exist within the prohibited limits, they should be removed following the procedures established under Section 7.2.4. The existing areas warranting attention include, but are not limited to, the east and west spillway dikes and upstream and downstream dam embankment slopes.

2. Repair the spalled areas of concrete on the spillway pier bridge seats and downstream face of the footbridge.

3. Repair the cracks in the concrete at the left downstream wall of the spillway discharge channel near Station 24+00 and at the headwall of the outlet works stilling pool.

4. Develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dam or other emergency conditions. The plan should be developed in cooperation with local officials and downstream inhabitants and should compliment the state's existing disaster operations plan, "Link-Up".

5. Continue with the present program of annual technical inspections performed in cooperation with the project's water users.

7.4 Alternatives

There are no practical alternatives to the above recommendations.

APPENDIX A - INSPECTION CHECK LIST

VISUAL INSPECTION PARTY ORGANIZATION
NATIONAL DAM INSPECTION PROGRAM

Dam: Murphy

Date: 22 April 1981

Time: 0730-1530

Weather: Clear and fair - Temperature in 30's

Water Surface Elevation Upstream: El. 1370.5 (NGVD)

Stream Flow: 15 cfs controlled discharge

Inspection Party:

Peter L. LeCount	-	Soils/Geology
Charles R. Nickerson		
Haley & Aldrich, Inc.		
Joseph E. Downing	-	Hydraulic/Hydrologic
Francis E. Luttazi	-	Structural/Mechanical
Camp, Dresser & McKee, Inc.		

Present During Inspection:

Richard W. DeBold (for part of the time) - Civil Engineer, NHWRB
David Chappel - Dam Operator, NHWRB

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	Designed maximum El. 1402.0 (NGVD) Designed minimum El. 1400.0 (NGVD), top of dam
Current Pool Elevation	El. 1370.5 (NGVD) Operator in progress of filling reservoir
Maximum Impoundment to Date	El. 1386.2 (25 May 1977)
Surface Cracks	None observed along crest or at abutments
Pavement Condition	No pavement; gravel wearing surface. From left abutment to approx. gate house wearing surface has thin coverage of vegetation; moss and grass has local bare spots (several square feet in areal extent) present, but no major erosion or rutting
Movement or Settlement of Crest	No significant movement or settlement of crest evident. Small local depressions from vehicle traffic present
Lateral Movement	None observed
Vertical Alignment	Visually, good to excellent, straight
Horizontal Alignment	Visually, good to excellent, straight
Condition at Abutments and at Concrete Structures	Good to excellent overall, at both abutments, unpaved service roads at either end of embankment are in good condition; embankment does not abut any concrete structures
Indications of Movement of Structural Items on Slope	No structural items on downstream slope. Gate house located at upstream slope; conditions at abutment of access bridge and at base of gate house do not indicate any major movement; see additional comments under "Outlet Works - Intake Control Tower"
Trespassing on Slopes	Dam site open to public, no barriers except fences; access restricted by Operator who attends to dam on daily basis, no vandalism observed

FILE NO 4454
HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Animal Burrows in Embankment	None observed; however, upstream and downstream slopes have riprap slope protection
Vegetation on Embankment	At crest as noted above under "Pavement Condition". Grass, brush, weeds moss and small (less than one inch in diameter) trees and tree stumps between riprap stones on downstream and upstream slopes
Sloughing or Erosion of Slopes or Abutments	No major sloughing or erosion of slopes or abutments observed. Erosion due to local runoff observed at both abutments and downstream slope but not of major areal extent
Rock Slope Protection - Riprap Failures	Surface of rock slope protection irregular at both upstream and downstream sides, evidently due to large size of stones; may possibly have been local settlement or original irregular placement
Unusual Movement or Cracking at or Near Toes	Local depressions and sink holes where fill placed over downstream rock fill toe; one hole extends approximately 7 ft. laterally under sod
Unusual Embankment or Downstream Seepage	Local standing or flowing water among rocks at downstream toe, particularly in vicinity of present beaver pond and former river channel; not major flow at any one location
Piping or Boils	No active piping or boils observed, but there is some silt and sand on bottom where flow enters beaver pond (see above); most of the sediment appears to have come from direction of road downstream of left abutment, but a small part seems to have come from rock at dam toe
Foundation Drainage Features	Downstream shell was designed to be constructed of pervious fill with large rock fill toe. A vertical 3 in. ID pipe at edge of beaver pond is flowing at an estimated 2 gpm and is understood to be monitoring/relieving hydrostatic pressure in old river bed below dam toe

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Instrumentation Systems	No internal embankment instrumentation systems present
EAST SPILLWAY DIKE EMBANKMENT	
Crest Elevation	El. 1400 (NGVD)
Current Pool Elevation	See DAM EMBANKMENT
Maximum Impoundment to Date	See DAM EMBANKMENT
Surface Cracks	None observed
Pavement Condition	Not applicable, crest approximately 20-ft. wide, with surface vegetation except where serves as gravel access road to dam
Movement or Settlement of Crest	None apparent
Lateral Movement	None apparent
Vertical Alignment	Good to fair overall, slightly irregular
Horizontal Alignment	Good to fair overall, slightly irregular at rock outcrop adjacent to left side of spillway
Condition at Abutment and at Concrete Structures	Left end abuts rock outcrop, condition good; no concrete structures
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	See DAM EMBANKMENT
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Mature tree growth at upstream slope. Crest and downstream slope mown grass. Large mature root systems traverse crest of dike. Also mature tree growth out of rock outcrop at left end, adjacent to spillway
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection - Riprap Failures	At upstream slope, condition obscured by mature tree growth
Unusual Movement or Cracking at or near Toes	None observed downstream, not observable upstream
Unusual Embankment or Downstream Seepage	None observed, upstream water level well below elevation of dike toe
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation Systems	None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
WEST SPILLWAY DIKE EMBANKMENT	
Crest Elevation	El. 1400 (NGVD)
Current Pool Elevation	See DAM EMBANKMENT
Maximum Impoundment to Date	See DAM EMBANKMENT
Surface Cracks	None observed
Pavement Condition	Not applicable, crest approximately 20 ft. wide with surface vegetation
Movement or Settlement of Crest	None apparent
Lateral Movement	None apparent
Vertical Alignment	Good overall but slightly irregular locally
Horizontal Alignment	Good, curved in good agreement with design drawings
Condition at Abutment and at Concrete Structures	Approximately 6-in. deep depression across width of crest and extending 4 ft. from right spillway training wall
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	None apparent - see DAM EMBANKMENT
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Crest mown grass in good condition, upstream slope riprapped with brush and stumps in voids, downstream slope thickly grassed, little brush and weeds and a few stumps
Sloughing or Erosion of Slopes or Abutments	Apparent at several locations in downstream slope,only local sloughing of surface vegetation possibly due to tree removal operations, slope at 2H to 1V, typically
Rock Slope Protection - Riprap Failures	At upstream slope only, riprap in fair condition, many stumps (up to 1-ft. in diameter) between stones. Cutting appears recent; much brush also present. Slopes at 2H to 1V, typically
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	None observed, upstream water level well below elevation of dike toe
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation Systems	None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
NORTH SPILLWAY DIKE EMBANKMENT	
Crest Elevation	Slopes from El. 1384 at upstream end to El. 1380 at downstream end
Current Pool Elevation	Spillway not conveying discharge during site visit
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Not applicable, sparse crest approximately 10 ft. wide with surface vegetation
Movement or Settlement of Crest	None apparent
Lateral Movement	None apparent
Vertical Alignment	Satisfactory, slopes gently down toward downstream toe
Horizontal Alignment	Satisfactory, slightly curved
Condition at Abutment and at Concrete Structures	Condition good at upstream abutment, no downstream abutment or concrete structures
Indications of Movements of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	None apparent - see DAM EMBANKMENT
Animal Burrows in Embankment	None observed, slopes covered with vegetation
Vegetation on Embankment	Crest mown grass; discharge channel slope riprapped, both slopes covered with well developed growth of weeds, brush and small trees
Sloughing or Erosion of Slopes or Abutments	Minor local sloughing
Rock Slope Protection - Riprap Failures	Riprap on discharge channel side of dike, slope irregular but at about 2H to 1V, typically
Unusual Movement or Cracking at or near Toes	None readily evident, but thick vegetation at toe of slopes
Unusual Embankment or Downstream Seepage	None observed, dike not retaining any water
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation Systems	None

11

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
SOUTH SPILLWAY DIKE EMBANKMENT	
Crest Elevation	Slopes from El. 1384 at upstream end to El. 1380 at downstream end
Current Pool Elevation	Spillway not conveying discharge during site visit
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Not applicable, crest approximately 10 ft. wide with surface vegetation
Movement or Settlement of Crest	None apparent
Lateral Movement	None apparent
Vertical Alignment	Good, slopes gently down toward downstream end in general agreement with design drawings
Horizontal Alignment	Good, straight
Condition at Abutment and at Concrete Structures	Condition good at upstream abutment, no downstream abutment or concrete structure
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	None apparent - See DAM EMBANKMENT
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Crest mown grass; spillway channel slope riprapped, both slopes covered with well developed, growth of weeds and brush
Sloughing or Erosion of Slopes or Abutments	Minor local sloughing and erosion due to runoff
Rock Slope Protection - Riprap Failures	Riprap on discharge channel side of dike, slope irregular but at about 2H to 1V, typically
Unusual Movement or Cracking at or Near Toes	None readily evident
Unusual Embankment or Downstream Seepage	None observed, dike not retaining any water
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation Systems	None

FILE NO. ...54

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CONTROL TOWER	NOTE: Intake control tower located on north side of U/S face of dam between center of dam and spillway approach channel. Access by concrete foot-bridge. Water level inside tower precluded examination of inside portion of structure.
a. Concrete and Structural	
General Condition	Good
Condition of Joints	Good
Spalling	None noted. Shrinkage cracks observed at spall repair of concrete portion at bearing seat for footbridge. Repair intact
Visible Reinforcing	None noted
Rusting or Staining of Concrete	None noted
Any Seepage or Efflorescence	None noted outside of structure with water level inside tower at 1370.5
Joint Alignment	Good - no exceptions noted
Unusual Seepage or Leaks in Gate Chamber	Submerged. During inspection of portion of conduit D/S of control tower, pressurized leakage was observed at lower right corner of roome head gate
Cracks	None noted in concrete portions of structure. Some cracking noted in outside brickwork adjacent to windows on each side of tower
Rusting or Corrosion of Steel	None noted
b. Mechanical and Electrical	
Air Vents	Good, no deficiencies noted in 24 in. diameter air vent. No obstructions noted
Service Gates	Gasoline powered cable hoist used to operate Broome head gate for intake conduit. Gate was lowered and raised during the site visit with no deficiencies noted. Leakage through gate as noted above

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Emergency Gates	24 in. diameter manually-operated by-pass gate. By-pass was operated during site visit with no deficiencies noted. No leakage through gate noted
Lightning Protection System	None noted
Emergency Power System	Manually operated by-pass gate
Wiring and Lighting System in Gate Chamber	Gate operator room at El. 1404.0 and chamber at El. 1385.0 well lighted with no deficiencies noted
Other	Access to the intake control tower is provided by a 5 ft. wide concrete footbridge. The bridge is generally in good condition with no deficiencies noted. Small repair at tower bridge seat was observed. Condition of bridge support pier at dam crest was noted without deficiency. Metal railing in sound condition. Minor weathering of deck observed. Joint detail at tower was operational
<u>OUTLET WORKS - TRANSITION AND CONDUIT</u>	NOTE: A walk-through examination of D/S portion of 13.0 ft. diameter conduit between stilling basin and intake control tower was performed.
General Condition of Conduit	Conduit lined with 7/16 in. steel plate which precluded inspection of concrete. Plate lining was in sound condition
Erosion or Cavitation	None noted. Interior surface of conduit was covered with rust tubercles and slime
Alignment of Joints	No deficiencies noted
Butterfly Valves	The 84 in. Dow valves in good condition. When closed with head gate open, moderate leakage through both gates was observed

FILE NO 4454

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 Ap

AREA EVALUATED	CONDITION
OUTLET WORKS - STILLING BASIN	
General Condition at Concrete	Good
Rusting or Staining	Some rust staining at intersectic headwall (above Dow valves) anc stilling basin wall. Lower por of headwall stained generally
Spalling	Minor spalling of right wall cons tion joint closest to control h noted. Cracking, apparently pr to spalling, noted at left cent lower portion of headwall
Erosion or Cavitation	Minor cavitation of concrete basi tom beneath each 84 in. Dow val noted
Visible Reinforcing	None noted
Cracks	Diagonal cracking across upper cc of top portion of headwall note Appear to be shrinkage cracks
Efflorescence	At crack noted above, lower porti headwall in general and D/S ver construction joint in left wall
Seepage	Continuous flow observed from wee furthest to the right in the he wall. Ice formation along leng lower portion of headwall benea the line of weep holes was obse and is apparently evidence of s seepage from these weeps or the zontal construction joint immec below the weeps
Condition of Joints	Good. Minor spalling and seepage noted above
Drain Holes	Six weep holes in lower portion c concrete headwall appeared unol structed. Steady seepage flow one as stated above
Basin Floor	Submerged. No deficiencies notec
Stop Logs	Three bays of stop logs in good tion allowing moderate leakage ing drawdown procedure. Two c piers defining bays and concre in good condition with no defi noted

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Service Gates	Manually operated by-pass gate in good condition; fully operable. Draw-down of basin facilitated with operation of gate during site inspection
Loose Rock or Trees Overhanging Basin	None noted. D/S portion of basin discharge channel is cut through bedrock, with left and right sides wooded
OUTLET WORKS - CONTROL HOUSE	NOTE: Operators for Dow butterfly valves and by-pass gates housed inside brick faced control house on concrete foundation.
a. Interior	
General Condition	Good. Interior clean and neat with no structural deficiencies noted. 6-ton manually operated crane hoist appeared in good operating condition. Hoist was not operated during site visit
Service Gates	Two 84 in. Dow valves operated electrically during site visit. Manual operation also possible. 30 in. Dow valve operated manually during inspection. No deficiencies noted in operation of any of the three gates
Emergency Power System	Gasoline powered engine available for operation of 84 in. Dow valves. Engine was started during inspection, however, it was not used to operate gates at that time
Wiring and Lighting System	One of four lights on ground level floor El. 1333.0 inoperable. Second level at El. 1322.0 was well lighted. Third level at approximately El. 1310 was without permanent lighting
Unusual Seepage or Leaks in Gate Chamber	None noted. Oil spillage, apparently from ongoing maintenance work, was noted and gas odor was noted

FILE NO 4454

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
b. Exterior	
General condition	Good. No deficiencies noted in brick-work or granite portions of control house. A few tiles were noted missing from roof
OUTLET WORKS - SPILLWAY WEIR, D/S TRAINING WALLS, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None noted. U/S slope of dike at right side of spillway protected with large size riprap. Bedrock upon which spillway is founded is visible at right side
Trees Overhanging Channel	Right and left banks wooded
Floor of Approach Channel	Partially submerged. Channel floor of coarse gravel, cobbles. Some brush present
b. Spillway Weirs, Piers and Abutments	NOTE: Four stanchion board bays and one flashboard bay on the far right from spillway weir between four concrete piers and the two concrete abutments. In addition, the piers and abutments support a concrete footbridge over the stanchion board bays and a structural steel footbridge over the flashboard bay.
Numbering of Piers	To facilitate this portion of the check list, the concrete piers have been numbered #1 through #4 from left to right
General Condition of Concrete	Good. Some repair work noted
Rust or Staining	Minor rust staining at right abutment from metal work of footbridge, and at concrete footbridge from metal railing

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Spalling	Some spalling noted at bridge seat at left side of pier #1, left and right sides of pier #2, right side of pier #3, and left and right sides of pier #4. Some spalling noted at D/S face of concrete footbridge between piers #1 and #2, and #3 and #4. Spalling and "hollow" concrete detected at D/S face of flashboard bay apron adjacent to pier #4. Spalling observed at top right abutment at bridge seat and U/S of bridge seat, and minor spalling noted at left U/S abutment at vertical construction joint
Cracks	Shrinkage cracking of mortar repair at left side of stairs at left abutment observed
Any Visible Reinforcing	At bridge seat at right side of pier #2
Any Seepage or Efflorescence	Some leakage noted beneath stanchion boards between left abutment and pier #1. Fill, apparently placed to retard leakage was observed on U/S side of stanchion boards. Some efflorescence at right side of stairs at left abutment, and at two vertical construction joints in the left abutment
Drain Holes	3 in. diameter vertical pipe weepholes 5 ft. on centers D/S of stanchion board bays. Water noted in several of these weepholes. However, no flow observed
Alignment of Abutments and Piers	Good. No deficiencies noted
Joints	General condition of joints is good. It appears that pier spalling at bridge seats noted above is an indication of working expansion joints in the concrete footbridge. Horizontal displacement of footbridge relative to right side of pier #4 was noted

FILE NO 4454

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
c. D/S Training Walls	NOTE: Length of walls not entirely accessible for close inspection.
Numbering of Training Wall Panels	Refer to Appendix B, "Inspection and Report by Chas. T. Main, Inc." Plate I for station locations
General Condition	Condition of right and left concrete training walls found to be generally satisfactory
Rust or Staining	None noted
Cracks	Several minor cracks noted over length of both right and left walls. Noticeable cracking of two adjacent panels in left wall near station #24. Vertical displacement of approximately 3/4 in. noted between portions of wall panel defined by U/S crack
Spalling	At cracks noted above near station #24. D/S of this location, portion of left wall is broken away and was observed within spillway discharge channel
Any Visible Reinforcing	None noted
Any Seepage or Efflorescence	Some efflorescence noted at cracks. Minor flow noted from weep in left wall panel at termination of spillway apron. The size and flow from the seepage pool at this location apparently indicates an additional source of seepage. However, none was confirmed
Drain Holes	Weeps built into both walls. No obstructions noted. Flow observed from one weep only, as noted above
Alignment	Good. No exceptions noted other than local displacement noted above under "Cracking"
d. Discharge Channel	
General Condition	Good

FILE NO 4454

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
Loose Rock Overhanging Channel	D/S portion of spillway cut through rock, portions of which overhang channel at right and left sides and are susceptible to freeze-thaw cycles. No substantial portions of loose rock noted
Trees Overhanging Channel	None noted. Right side is wooded
Floor of Channel	Bedrock. Some brush present
Other	See checklist notes concerning seepage at left D/S Training Wall
<u>OUTLET WORKS - SERVICE BRIDGE AT SPILLWAY WEIR</u>	
a. <u>Concrete Footbridge</u>	3 ft. thick, 6.5 ft. wide concrete beam spans each of four stanchion board bays isolated by expansion joints at each of four piers. Provides support for, and access to, stop log stanchions. Good general condition
Bridge Seats	Generally in good condition. As previously noted, spalling observed at bridge seats at four piers; visible reinforcing at one. No exceptions at left abutment
Under Side of Deck	Good, no deficiencies noted
Deck	Generally in good condition. Moderate scaling observed. Some repair work observed. Spalling noted at downstream face of deck
Drainage System	None noted
Railings	Good condition
Expansion Joints	Operational. No deficiencies noted. Caulking is sound with no noted impregnation of foreign matter
Abutment and Piers	See "<u>Outlet Works - Spillway Weir, D/S Training Walls, Approach and Discharge Channels</u>

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Murphy DATE: 22 April 81

AREA EVALUATED	CONDITION
b. Structural Steel Foot-bridge	
Superstructure	A light structural steel truss foot-bridge, in good general condition, spans flashboard bay at right side of spillway
Bearings	Good
Anchor Bolts	Good
Bridge Seat	Spalled at right abutment
Longitudinal Members	Good. Structural adequacy apparent, however, bridge noted to be flexible
Under Side of Deck	No deficiencies noted
Secondary Bracing	Good
Deck	Bar grating, one section of which was noted to be bent and loosely secured with wire
Drainage System	None
Railings	Good condition
Expansion Joints	None
Paint	Minor spot rusting of steel members is generally noted

APPENDIX B - ENGINEERING DATA

LIST OF AVAILABLE DATA
MURPHY DAM

Document	Contents	Location
Report	Draft Inspection Report of the New Hampshire Water Resource Board Murphy Dam - Inspection & Report by Chas. T. Main, Inc., Boston, Massachusetts, September 1977	New Hampshire Water Resources Board Concord, New Hampshire
Report	Inspection Report of the New Hampshire Water Resources Board Murphy Dam - Inspection & Report by Chas. T. Main, Inc., Boston, Massachusetts, November 1977	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg-Hydraulic Data & Emergency Operation Procedures for Pittsburg Reservoir During Period of High Inflow to be Followed by Operator if Communication with Advisors Is Not Possible, 26 March 1977	New Hampshire Water Resources Board Concord, New Hampshire (pages B-43 through B-46)
File Folder	Pittsburg-1974 Inspection of Murphy Dam & 1st and 2nd Lake Dams • Site Evaluation Data, 31 July 1980 • Miscellaneous Photos, Not Labeled • Murphy Dam Inspection-194.12 Pittsburg, 24 October 1974 (& New England Power Company Report), 18 October 1974 • Request Proposal for Inspection of Murphy Dam, 13 October 1976	New Hampshire Water Resources Board Concord, New Hampshire (pages B-30 through B-41)
File Folder	Pittsburg-Repairs	New Hampshire Water Resources Board Concord, New Hampshire (page B-42)

LIST OF AVAILABLE DATA
MURPHY DAM
(continued)

Document	Content	Location
File Folder	Lake Francis Storage Data-Pittsburg	New Hampshire Water Resources Board Concord, New Hampshire
Report	New Hampshire Water Resources Board-Murphy Dam-Study of Spillway and Discharge Channel - Chas. T. Main, Inc., 21 August 1958	New Hampshire Water Resources Board Concord, New Hampshire (pages B-5 through B-17)
File Folder	Lake Francis Soundings 1960-Pittsburg, March 1960	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Maintenance-Road & Garage	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Dam 1951	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg-Pier Failure, 23 January 1964	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg-Campgrounds	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Lake Francis Pittsburg Studies	New Hampshire Water Resources Board Concord, New Hampshire

LIST OF AVAILABLE DATA
MURPHY DAM
(continued)

Document	Contents	Location
File Folder	Pittsburg Survey Notes 1972 & 1957	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Erosion Survey Data, 1960	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Temperature Data	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Design of Service Building-Pittsburg	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Dam Survey 1950	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Gauging Station Conn. River	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Flashboard Details in Spillway and Stanchion Bays	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Traverse Data 1949	New Hampshire Water Resources Board Concord, New Hampshire

LIST OF AVAILABLE DATA
MURPHY DAM
(continued)

Document	Content	Location
File Folder	Pittsburg (Murphy) Inspection w/C. Main	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Toilet Facility	New Hampshire Water Resources Board Concord, New Hampshire
File Folder	Pittsburg Lots	New Hampshire Water Resources Board Concord, New Hampshire
Data Sheet	Pittsburg Dam - Operating Record	New Hampshire Water Resources Board Concord, New Hampshire (page B-47)

NEW HAMPSHIRE WATER RESOURCES BOARD

MURPHY DAM
STUDY OF SPILLWAY AND DISCHARGE CHANNEL

CHAS. T. MAIN, INC.

BOSTON, MASSACHUSETTS CHARLOTTE, NORTH CAROLINA

1318-7-1 August 21, 1958

B-5

F. M. GUNBY
W. F. UHL
W. M. HALL
R. W. LOGAN
M. JACOBS
S. R. RICH
H. T. COLBURN

CHAS. T. MAIN, INC.
80 FEDERAL STREET
BOSTON 10, MASS.

INDUSTRIAL PLANTS
TEXTILE MILLS
PAPER MILLS
PRINTING PLANTS
STEAM POWER
WATER POWER
FOUNDATIONS
VALUATIONS

CABLE ADDRESS
CHASMAIN, BOSTON

129 WEST TRADE STREET
CHARLOTTE, N. C.

August 21, 1958

1318-7

Subject: Murphy Dam

Mr. Walter G. White, Chairman
New Hampshire Water Resources Board
State House Annex
Concord, New Hampshire

Dear Mr. White:

Pursuant to your request we have studied the Murphy Dam spillway arrangement in the light of information developed since its construction. Our report is submitted herewith. Briefly, our conclusions and recommendations are as follows:

I. Reservoir elevations and spillway discharges were determined under the assumption that a hurricane storm, similar to that of August, 1955, would travel to the area without appreciable diminution. Under this very conservative assumption the dam would still retain about 6.0 feet of freeboard. No apprehension whatever need therefore be retained regarding its safety.

The south bulkhead wall of the spillway might, however, be overtopped about one foot. The spillway discharge channel banks might also be overtopped. Neither of these would endanger the safety of the dam but they might carry debris to the outlet building area. We, therefore, recommend that the bulkhead wall be raised 2 feet by additional concrete, that the discharge channel be widened in the deep rock cut just above the highway bridge, that the downstream portion of the discharge channel be cleared of loose rock and bottom irregularities, and that the material obtained from these latter be used to construct small dikes along the upper portion of the channel banks. We estimate that this work would cost in the order of $20,000.

II. We further studied the spillway operation under a series of floods that reasonably can be expected to answer certain questions asked by Mr. Leonard R. Frost. Our conclusions are:-

a. The present flashboards in the stanchion bays add nothing of consequence to the safety of the dam. They generally increase the peak spillway discharges. Although they have some advantage in decreasing flashboard and stanchion loss, this is slight and we see no reason that the stop logs should not be replaced. We particularly recommend that they be replaced if the reservoir is being held down, and water wasted, for fear of losing flashboards or if it is decided to keep the outlet valves closed during floods.

Mr. Walter G. White, Chairman August 21, 19

b. Keeping the outlet valves closed during floods would decrease the peak discharge in a good many cases but in others would have little advantage and in some would actually cause an increase. From the tangible evidence we cannot recommend this procedure although we can offer no strong objections if there is an intangible advantage. We definitely do not recommend a procedure whereby the gates are left closed and then opened on incipient flashboard failure.

c. Holding the reservoir below full stage has no advantage either from a flood control or flashboard failure standpoint that should, in our opinion, dictate this mode of operation.

d. Mechanical means for raising and replacing top sections of the flashboards are not economically justifiable.

e. A stock of spare parts for one stanchion bay is amply warrante These would cost in the order of $1,500.

We trust that the above gives you everything you desire on the matter. Plea let us know if we can do something further.

Yours very truly,

CHAS. T. MAIN, INC.

By C. C. Cullum

C. C. Cullum

CCC.vrd

F. M. GUNBY
W. F. UHL
W. M. HALL
L. W. LOGAN
A. JACOBS
R. RICH
T. COLBURN

CHAS. T. MAIN, INC.
80 FEDERAL STREET
BOSTON 10, MASS.

INDUSTRIAL PLANTS
TEXTILE MILLS
PAPER MILLS
PRINTING PLANTS
STEAM POWER
WATER POWER
FOUNDATIONS
VALUATIONS

CABLE ADDRESS
CHASMAIN, BOSTON

129 WEST TRADE STREET
CHARLOTTE, N. C.

August 21, 1958

1318-7-1

NEW HAMPSHIRE WATER RESOURCES BOARD

MURPHY DAM
STUDY OF SPILLWAY AND DISCHARGE CHANNEL

A. SCOPE

This report covers a study of the Spillway for Murphy Dam to determine, in the light of rainfall and flood records accumulated since its construction:

1. Whether its capacity is now considered adequate to provide for the safety of the dam under extreme flood conditions.

2. Whether the discharge channel will carry such flood flows safely past the dam.

3. What measures would be recommended to correct any deficiencies.

It also covers studies of the Spillway operation under smaller freshets, occurring principally during the summer months when the pond is most nearly full, to answer the following questions:

1. Should the flashboards now installed in the spillway stanchion bays be replaced by stoplogs as originally designed?

2. In time of flood, should the outlet valves remain closed so that all flood flows are passed over the spillway?

3. Is there any decided advantage, either as regards flood control or flashboard operation, in having the reservoir below normal full level (say Elev. 1383)?

4. Should some mechanical means be provided for raising top sections (about 2 ft.) of the stoplogs and quickly replacing them near the end of a flood?

5. Should spare parts be stocked for the stanchion bays?

B. EXTREME FLOOD

Subsequent to completion of the project, several hurricane storms have dumped enormous quantities of water over the New England area.

Notable among these, besides the storm of Sept.17-21,1938 when the project was under construction, were six which occurred in 1954 and 1955. The principal storm, as regards intensity and quantity of rainfall, with attendant extreme run-off, was "Diane" of Aug. 17-19, 1955 with its antecedent storm "Connie" of Aug. 11-15, 1955.

None of these storms reached the Pittsburg area. However, certain of them have traveled inland into Pennsylvania a comparable distance so that such a possibility should be taken into account.

Hurricane storms occur in August and September, at a time when the reservoir is, a good part of the time, fairly well filled. At the end of the months of July, August and September the following elevations were recorded for the years 1940-1955 inclusive:

Maximum Elevation	-	1383.9
10% Time Above	-	1382.8
20% Time Above	-	1381.6
Mean	-	1378.3
20% Time Below	-	1371.8
10% Time Below	-	1368.3
Minimum Elevation	-	1356.1

The condition of inflow to a high reservoir from a hurricane storm is the most critical for spillway capacity. The combination of a warm rain on heavy snow cover might produce as great, or greater, inflows but this would occur during the period when the reservoir would be drawn down.

Accordingly, the spillway capacity was checked, based on the following criteria, with the realization that these criteria are extremely conservative:

Maximum Rainfall, 30 hrs.	- 18.0"
Total Run-off	- 15.0"

Hydrographs were developed for the various portions of the drainage area. The inflow above Second Connecticut Lake was first routed over Second Connecticut Lake Dam. The discharge, plus the intervening flow between Second and First Lakes was then routed over First Connecticut Lake Dam. This discharge, plus the discharge from Perry Stream and the intervening area, was then routed over Murphy Dam Spillway. Plate I shows a hydrograph of inflow and of outflow, with corresponding Lake Elevations. The following are cardinal points:

Maximum Inflow - 72,000 cfs
Maximum Outflow - 51,300 cfs (incl. valve discharge)
Maximum Spillway Discharge - 49,300 cfs
Maximum Reservoir Elev. - 1,394.1

The above is for the present arrangement of flashboards and the present operation procedure instructions of New England Power Service Co.

C. SPILLWAY CAPACITY

The above indicates the following with respect to the dam and spillway:

1. Under the worst conditions the earth dam would still have almost six feet of freeboard. It is, therefore, perfectly safe against overtopping.

2. The spillway operating bridge would be overtopped about one foot. This bridge, however, is a heavy (3 ft. thick) concrete slab and is adequate to withstand such a condition.

3. The concrete bulkhead wall at the south end of the spillway would also be overtopped about one foot. The overflow would be directed away from the toe of the main embankment so that the safety of the dam would not be jeopardized. However, there might be other fairly serious conditions:

(a). Backfill against the bulkhead could be washed away to such an extent that the wall would be unstable and a portion might fail. This, however, could not be sufficient to cause a serious peak in the discharge, nor is it probable that failure would be below spillway level so that no more than a normal amount of reservoir storage would be lost.

(b). The overflow, and particularly the discharge from a wall failure, would be directed towards the outlet building. This flow and the materials brought down by scour from the hillside could cause considerable damage to the outlet works:

It is recommended that this wall be raised 2 feet by additional concrete. About 10 cu. yds. of concrete would be required, which should cost in the order of $500.00.

D. DISCHARGE CHANNEL

The hydraulics of the channel was checked under the condition of maximum spillway discharge (49,300 cfs. - Par. B, above). It was found that the channel will not contain this flow beyond about Sta. 23+00. Plate II is a profile of the channel showing maximum water surface levels and the ground line along its banks.

Overflow on the south side would follow the same general path as discussed above for flow over the spillway bulkhead wall (Par. C,3,b). Again, there could be considerable damage to the outlet works. Overflow on the north side would very likely cause serious erosion along the escape route to the brook leading west. The remote possibility of such an occurrence however does not justify major expenditure. For instance, if we assume $1,000,000 damage with 1,000 year recurrence (actually, the probability may be greater), we could justify an annual cost of $1,000 or, with 4% annual charges, a capital expenditure of $25,000.

The following is, therefore, recommended:

1. Widen the channel below station 23+00 ± to 26+00 ± by excavation of a 10 ft. wide berm on the south side at the level of the top of the concrete side walls. This will provide sufficient area to prevent a hydraulic jump and keep the flow at sub-critical stage.

2. Construct a berm along the south side of the channel from Sta. 23+00 to Sta. 25+50 up to the maximum water surface level. Extend the inside face of this berm with riprap down to the top of the concrete side wall.

3. Construct a dike on the north side across the draw between Sta. 22+00 ± and Sta. 24+00 ±. This dike would be well back from the channel so as to be safe from possible erosion of the earth slope above the concrete side wall.

Material for this construction would come from the excavation and from cleanout of the channel downstream from the highway bridge. This latter should be done in any case. Plate II also shows a suggested section of the excavation and of the berm, although final design will require a better survey of the ground than is now available. The same is also true as regards location of the dike recommended under 3.

The following is a preliminary estimate of cost:

Channel Widening, Earth Excavation	- 600 c.y. @	$1.00 =	$ 600.00
Channel Widening, Rock Excavation	- 500 c.y. @	$8.00 =	4,000.00
Channel Cleanout	3,000 c.y. @	$1.25 =	3,750.00
Placing Fill	3,200 c.y. @	$0.25 =	800.00
Placing Riprap	860 c.y. @	$5.00 =	4,300.00
Clearing & Misc.		L.S.	2,000.00
Engineering & Contingencies		L.S.	2,550.00
Total			$18,000.00

Beyond Sta. 26+00 the flow would spread out on either side of the channel. The highway bridge crossing the channel would be overtopped and and might or might not be seriously damaged. The bridge abutment would unquestionably be washed out. All of the conditions had been foreseen in the original design and the decision was made that the expenditure required to alleviate them was not warranted. Access to the dam for operation would still be possible. There is no substantial change from these original considerations so that expenditure for remedial measures in this area is not deemed justified at this time.

Velocities in the unpaved section of the channel would be in the range of 30 ft. per. sec. under the maximum conditions above outlined. An unpredictable amount of erosion would therefore take place. Paving the bottom is, however, not considered justified. The cost would be in the order of $75,000.00.

It is further recommended that the pool just below the highway bridge be pumped out to see if there has been any undercutting of the retaining walls and that any necessary repairs indicated be made.

E. SPILLWAY OPERATION AND FLASHBOARD ARRANGEMENT

In order to study the spillway operation and flashboard arrangement, storms of varying sizes were routed through the reservoir, first assuming the initial reservoir at Elev. 1383 and then at Elev. 1385. These were as follows:

STORM I. - 1" run-off in 3 hrs.(equivalent to about 1½" rainfall). This is an ordinary heavy thunderstorm and might be expected to have a return period of about 4 years for the entire year, or possibly 8 to 10 years for the critical summer period. It would produce a peak inflow of about 4,200 cfs. Actually, three storms in this order of magnitude have been experienced since the project was completed: in 1942, 1945 and 1947.

STORM II. - 2" run-off in 3 hrs. (equivalent to at least 2½" of rainfall in 3 hours or considerably more over a longer period). This is a fairly heavy rain and might be expected to have a return period of at least 25-30 years for the summer period. It would produce a peak inflow of about 8,000 cfs. No storm in this order of magnitude has been experienced since the project was completed.

STORM III. - Equivalent to the storm of June 15-16, 1943. Rainfall during this storm, and the antecedent rain, was as follows:

June 10 & 11	-	1.85"
June 12	-	0.27"
June 13	-	0.23"
June 14	-	0.00
June 15 & 16	-	4.45"

Rain fell throughout the 15th and during the early morning of the 16th, with a significant period of about 24 hours. The actual rainfall of the 15th has a return period of about 20 years for the entire year. However, with the antecedent conditions which would saturate the ground and cause a heavy run-off as well as bring the reservoir to nearly full stage in any year, the return period should be no less than 75 years during the critical summer and early fall period. The actual run-off was about 3.4", indicating the very low retention of about .05" per hour. The peak inflow was 19,600 cfs, according to data furnished by N. E. Power Service Co.

Table A shows the maximum outflow (including outlet valve discharge) and maximum reservoir elevations for the various storms and for the following flashboard arrangements and operating procedures:

Case A - Present flashboards and present New England Power Service Co.'s operating instructions.

Case B - Present flashboards in stanchion bays replaced by stoplogs and present rules regarding operation of outlet valves during floods.

Case C - Same as B, except outlet valves to remain closed during floods.

Study of Table A and the data below indicates the following regarding the questions set up in paragraph A:

1. Should the Stoplogs Be Replaced? The present flashboards in the stanchion bays add nothing of real significance to the safety of the dam. They were apparently installed to afford the following presumed advantages:

(a) Less loss of Bay #5 flashboards. However, since these would go off with the stoplogs replaced only under a flood having a return of greater than 30 years and there would be a gain in reservoir elevation of only 0.2 to 0.4 ft., this advantage is largely theoretical.

(b) Less likelihood of having to drop stanchions. Again, since this has an expectancy in the order of 1 to 100 and the next flood of this magnitude cannot be predicted with the accuracy required to determine whether they would have to be dropped in either case, the advantage is theoretical.

The peak discharges are greater for the present arrangement except for mall floods where no flashboards fail or for large floods where stanchions ave to be dropped. However, unless this greater discharge (about 25%) has eal significance there is no decided tangible difference between the two rrangements. Data are not available to properly evaluate any intangible ifferences and it appears that the weight of these differences should govern e decision as to whether or not the stoplogs should be replaced. It is finitely recommended, however, that they be replaced (or at least in Bays #2 d #3 which now have the weakest pins) if the reservoir is being held down d water wasted for fear of losing flashboards, or if it is decided to keep e outlet valve closed during floods.

2. Should the Outlet Valves be Closed During Floods? It is finite that the valves should be operated as at present unless the present ashboards in the stanchion bays are replaced by stoplogs. Otherwise, these rds will go off at fairly regular intervals. When a bay fails, the disarge over the lowered crest will approach, and in some cases will exceed, e gate capacity. Referring to Table "A", Bays No. 2 and 3 would fail under orm I if left in place. The peak discharge would then be 2,320 cfs as compared with 2,200 cfs with the valve used or with the stoplogs replaced.

Assuming that the stoplogs are replaced in the stanchion bays, flashboards must remain in the overflow section (Bay No. 5). Peak outflows here again would be worsened for a flood that could be held below failure level by use of the valves and that would cause failure without their use. (Reference Table "A", Storm III). The same is true for a flood that is on the borderline for dropping of stanchions. These conditions, however, are rare. Under the great majority of cases the peak outflows would be decreased in the order of 1,000 cfs.

A procedure whereby the gates would remain closed until incipient failure of a bay of flashboards and then be opened would be advantageous only in the rarest of instances. It would be dangerous without highly efficient flood forecasting and perfect control of the operation. Inaccurate flood forecasting would run the risk of adding the gate discharge unnecessarily or of superimposing the gate discharge on the flashboard failure discharge, the latter being the more likely.

3. What Are the Advantages in having the Reservoir below Full Level?

(a) For flood control, holding to Elev. 1383 has some but no great advantage. It reduces outflow peaks in the order of 1,000 cfs for all sizes of floods.

(b) For flashboard operation. Under the present spillway dressing, maybe once every 10 years or so a flashboard failure would be saved by holding the reservoir low but this is of no great advantage provided the reservoir can be refilled on the tail end of a flood. There is no reason that this should not be possible. If the stoplogs are replaced, the consideration is even less.

(c) For storage. It is customary to allow room in Storage reservoirs for local storms. One foot in this case would appear to be enough. This allows 0.43" run-off on the 87 sq. mi. below First Lake which is equivalent to 3/4" - 1" rainfall under dry conditions.

It would therefore appear that power consideration should govern and that the reservoir should be filled as completely as the available inflow allows, provided that this will result, in the judgment of the operators, in the least wastage of water.

4. Should Mechanical Means be Provided for Handling the Top Section of Stoplogs?

A fairly simple trolley beam arrangement could be worked out for handling the top section (say about 2 feet) of the Stoplogs (provided they are replaced). The cost should be in the order of $25,000. Annual charges might be:

Interest	-	3.00%
35-50 yr. Sinking Fund		0.89%
Maintenance		0.11%

4.00% x \$25,000 = \$1,000.00

The value might be calculated as follows:

(a) Say, probability of Bay #5 flashboards going out is:

One in 30, without removable boards
One in 40 with removable boards
One in 120 as the difference

Assume lose stored water - Elev. 1383-1385 = 1,710,000 kwh.

Value of power loss @ $\frac{1}{2}$¢/kwh = \$8,550.00

Annual value of power loss = \$8,550/120 = \$71.25

(b) Say, probability of Stanchions being dropped is:

One in 100 without removable boards
One in 150 with removable boards
One in 300 as the difference.

Assume lose stored water- Elev. 1375-1383 = 6,585,000 kwh

Value of power loss @ 1/2¢ /kwh = \$32,930

Annual Value of power loss 32,930/300 = \$109.80

Annual Charge justified = \$71.25 + 109.80 = \$181.05

The Annual Charge of \$1,000 is therefore clearly not justified.

5. <u>Should Spare Parts for Stanchion Bays be Stocked?</u>

As above, assume that probability of at least one stanchion bay being dropped is one in 100. The justified annual charge would thus be:

\$32,930/100 = \$329.30

Cost of replacement parts for one bay (3 stanchions plus complete stoplogs) is about - \$1,500.

Annual Charges - 4% x 1,500 = \$60.00

It is probable that, even with the replacement parts on hand, installation could not be made in time to save more than one-half of the storage loss. Nevertheless, purchase of replacement parts for at least one bay is amply justifiable.

TABLE A

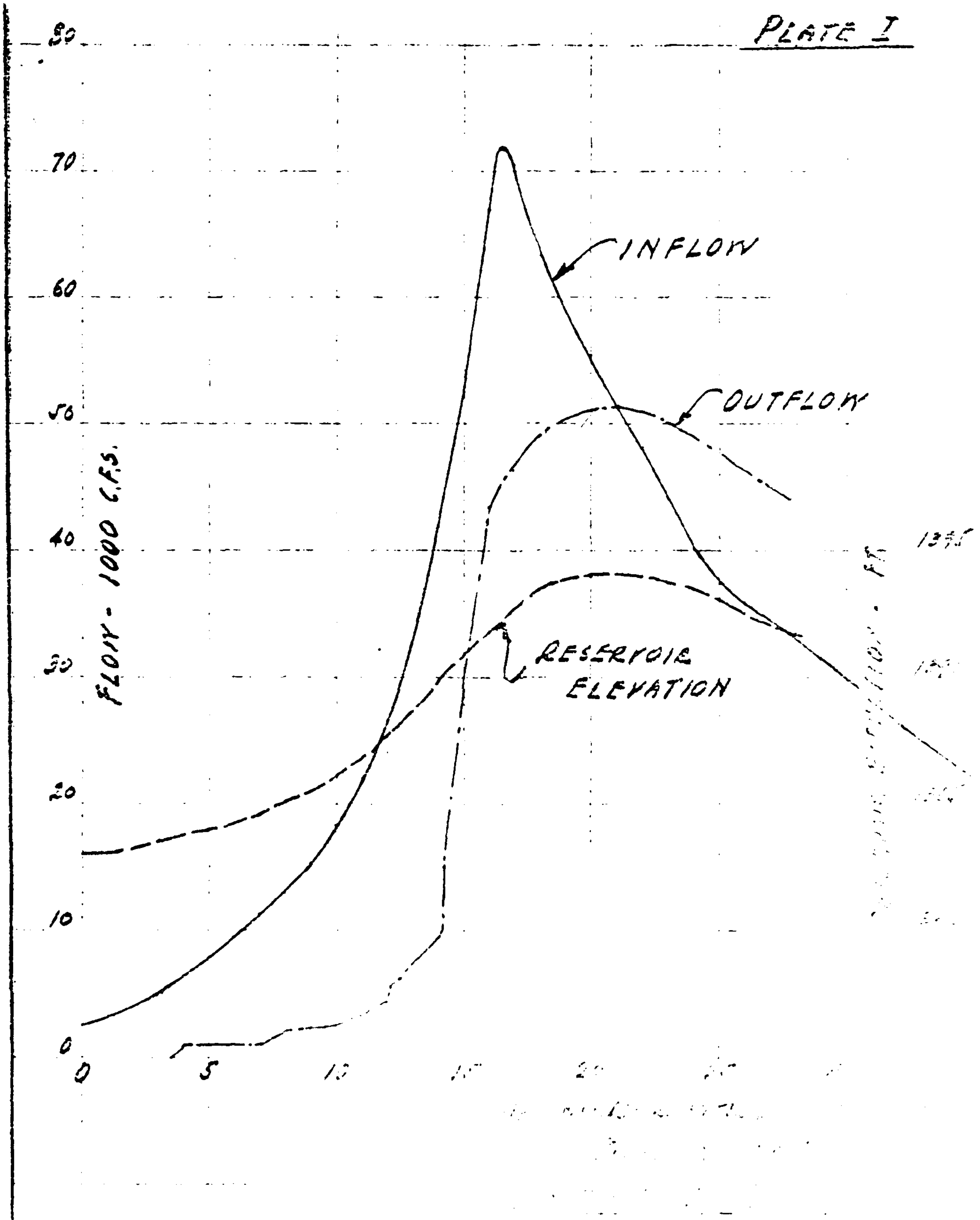
MURPHY DAM FLOOD ROUTING

Summary

	Case A Present Conditions and Rules		Case B Stop Logs Replaced Present Valve Use		Case C Stop Logs Replaced No Valve Use	
	1383	1385	1383	1385	1383	1385
Storm I-(1" Run-off/3 hrs.)	(8-10 Year Return During Summer)					
Max. Discharge, cfs.	1,430	2,200	1,430	2,200	80	1,130
Max. Res. Elev. Ft.	1385.0	1385.5(1)	1385.0	1385.5	1385.3	1386.6(2)
Storm II-(2" Run-off/3hrs.)	(25-30 Year Return During Summer)					
Max. Discharge cfs.	3,200	4,500	2,580	3,500	1,400	3,870
Max. Res. Elev. Ft.	1385.9(3)	1386.5(4)	1386.1	1386.9(5)	1386.8(5)	1387.7(6)
Storm III-(June 15-16, 1943)	(At least 75 Year Return During Summer)					
Max. Discharge, cfs.	9,300	10,400	7,280	8,500	6,500	7,800
Max. Res. Elev. Ft.	1387.9(7)	1388.5(7)	1388.5(6)	1389.1(6)	1389.1(6)	1389.9(8)
Storm IV-(Maximum)						
Max. Discharge, cfs	51,300		51,700		51,200	
Max. Res. Elev. Ft.	1394.1	(9)	1394.2	(9)	1394.6	(9)

Notes:
(1) None of the Flashboards go off.
(2) No. 2 and No. 3 bays of Flashboards, if left in place, would go off without use of valve and maximum discharge would be 2,320 cfs.
(3) No. 2 Bay Flashboards go off.
(4) No. 2 and No. 3 Bays of Flashboards go off.
(5) Note that No. 5 Bay Flashboards would not go off.
(6) No. 5 Flashboards go off.
(7) All Flashboards go off.
(8) Theoretically, some stanchions should be dropped.
(9) Not figured, would be about 0.1 ft. higher than for Res. El. 1383.

1318-7-1


INFLOW
OUTFLOW
RESERVOIR ELEVATION
FLOW - 1000 C.F.S.
80
70
60
50
40
30
20
10
0
0
5

MEMORANDUM

[illegible] Stockwell — Lebanon — [illegible] 22, 1970
G. D. Bacon/
H. H. Bloomfield — Westboro - 417

[illegible] -- [illegible] DAM -- PITTSBURG[illegible], NEW HAMPSHIRE

On December 4, 1970, it was reported that the No. [illegible] Dow [illegible] valve at Murphy Dam was inoperative. The operation of the electric motor drive resulted in no change of the butterfly disc.

An inspection was scheduled for December 9th and 10th, with the following present:

Francis Moore	-	New Hampshire Water Resources
Charles Harrington	-	NEPCO, Lebanon
Howard Bomhauer	-	Comerford Station
Stewart Lewis	-	Comerford Station
G. D. Bacon	-	NEPSCO, Westboro
H. H. Bloomfield	-	NEPSCO, Westboro

The inspection on December 9th indicated the Dow valve operating shaft was intact through the stuffing box; therefore, the decision was made to unwater the penstock in order to inspect the Dow valve.

On December 10th, the intake broome gate was closed and the penstock and downstream stilling pool were drained. On inspection, it was found that the pin that connects the connecting rod to the butterfly disc had fallen out. The two set screws that hold the pin in place had backed out, thus allowing the pin to fall out. The pin was found in good condition in the lower section of the stilling pool.

The pin was reinstalled and secured with two set screws which were locked with two additional set screws. After the repair, the valve operated satisfactorily.

The connecting rod which connects the cross head of the motor operating shaft to the butterfly valve disc was found to be severely cavitated through its midsection. The original 4-1/2" diameter of the connecting rod has been reduced to 3-1/2" diameter or a 40% loss of section.

Future consideration should be given to replacing the connecting rod or, as an alternate, weld a section of stainless steel tubing sleeve around the midsection to arrest further cavitation and erosion. The downstream portion of the deflector, which is attached to the valve body, was found to be badly cavitated. This could be repaired by cutting out the section and welding in a preformed section of 3/4" steel plate.

The No. 1 valve was inspected, and a locking set screw was installed on one end of the connecting rod pin to prevent its backing out. The midsection of the connecting rod has been reduced from 4-1/2" diameter to

a 4" diameter by cavitation, or a 20% reduction in area. Consideration should be given to encasing the midsection of the connecting rod with a stainless steel sleeve to prevent further loss of section. The deflector was found in about the same condition as on No. 1 valve.

On Thursday, December 10th, while the penstock and stilling pool was drained for repairs to the Dow valve, an inspection of the concrete of the stilling pool and the steel penstock was made by F. Moore, H. Lodhauer and G. Bacon. Both structures were found to be in safe operating condition.

The top of the concrete walls of the stilling pool were covered with ice and snow, so could not be inspected at this time, but will be exposed for inspection during the warmer seasons. The concrete of the walls and floor was in good condition, no areas of spalling were found and only minor areas of ravelling, mostly along construction joints, were observed.

The 13 ft. diameter riveted steel penstock is in good condition. There is a thin coating of algae and numerous round (1-1/2" diameter) rust tubercles over the entire interior surface.

The broome type head gate was not inspected because of the leakage at the bottom of the gate with streams of water jetting out a distance of 15 to 20 feet.

All future inspection parties should be cautioned concerning the 30" diameter bypass opening located in the bottom of the penstock at the upstream end of the venturi.

GDB:cf

DATE: December 28, 19[illegible]

FROM: [illegible]
Water Resources [illegible]

SUBJECT: Inspection of Gates and Penstock - Murphy Dam

TO: Vernon A. [illegible]
Chief Water Resources Engineer

On December [illegible], 19[illegible], I inspected the control and head gates and penstock [illegible] the control gates with New England Power Company engineers at Murphy Dam. The following findings are reported:

No. 1 gate at the control house had lost its pin connecting the gate and connecting rod. The [illegible] guides around the connecting rod were burred by hammering of the gate against the connecting rod. The pin was retrieved near the right stilling basin wall upstream of the stop logs. It was not damaged. New set screws were inserted [illegible] hold the replaced pin. New England Power Company mechanics performed the task.

No. 2 gate was opened and the pin inspected. One of two set screws was replaced as the old one was removed. The other set screw could not be retrieved and was not replaced.

The connecting rod to Gate #1 has a cross section of 3 1/2" against its original 4 1/2" due to cavitation in 30 years. This gives about 60% of original strength. At Gate #2, the cross section was 4" or about 80% of original strength. These connecting rods should be replaced within ten years and No. 2 gate should be used in place of Gate #1 whenever possible.

Both deflectors around the connecting rods should be built [illegible] stream edges are badly cavitated. This could be done by welding [illegible] shells around the deflectors. This is not a serious [illegible] acceleration of cavitation.

The small gate at the control house was not inspected as [illegible] not subject to such high velocities - normally only 5 [illegible]

The stilling basin is in good condition and stop logs do [illegible] (replaced a year ago). The by pass valve (30") operated [illegible] minimum flow (n t exceeding a few c.f.s.) the pool was about [illegible] crete work under the control house is in very good condition.

An inspection of the penstock was made accompanying a New England Power Company engineer and mechanic. The steel lining is in good condition with minor turbulation and scaling of algae. The head Broome gate seated fairly well and after dumping cinders in front of it, only some leakage at the bottom but little around the edges. The head gate by pass valve closed well although it had to be warmed from sub-freezing temperatures.

B-20

After the inspection of the penstock and repair to Gate #1, the control house gates were closed and permitted only nominal leakage. The head gate by pass gate was opened 2/3 way and water filled the [illegible]

Then the Broome gate was raised and by pass gate partly [illegible]. After th[illegible] operations at the head gate house, Gates #1 and #2 [illegible] to allo[illegible] 500 c.f.s. flow in each.

On December 9, the inspection by New England Power Company [illegible] and mechanics was made and it was decided to dewater the penstock. The [illegible] gate was lowered to near the top of penstock and the head gate house heat[illegible] by a portable furnace from 4:00 p.m. to 10:00 p.m.

On December 10, the Broome gate was closed at [illegible] a.m. as well as the by p[illegible] gate in the head gate tower. At the control house the small gate and Gat[illegible] were opened full. The flow still being excessive, cinders furnished by New England Power Company from First Connecticut Lake dam were placed upstream [illegible] the Broome gate cutting the flow to an acceptable amount. The repairs and [illegible]spection were made between 11:00 a.m. and 12:15 p.m. During the noon hour [illegible] small head gate by pass gate was opened to fill the penstock. The Broome [illegible] was opened at 1:30 p.m. to above the penstock.

The by pass gate to the stilling basin was closed and later in the [illegible] Clesson Covill raised the Broome gate to its top position.

New England Power Company personnel arrived at 10:45 a.m. on December 9 in[illegible] an engineer from Lebanon and three mechanics from Comerford and left about [illegible] On December 10, three engineers, two from Westboro, Massachusetts, arrived [illegible] a.m. and four mechanics. Also, Lindsey Covill arrived with cinders about [illegible] and worked with the crew. George Carlyle visited the site (from First Con[illegible] for a time. The engineers and mechanics completed work about 12:15 p.m. an[illegible] after eating lunch. It should be noted that the Massachusetts engineers we[illegible] just prior to noon, December 9, and drove up, arriving at Colebrook House a[illegible] p.m. Three engineers stayed at Colebrook Motel over night.

FCM/jb

NEW ENGLAND POWER COMPANY 20 West Park Street, Lebanon, New Hampshire 03766
New England Electric System

January 6, 1971

Mr. George McGee, Sr., Chairman
Water Resources Board
State House Annex
Concord, New Hampshire 03301

Dear Mr. McGee:

As you are aware the inspection and determination of the problem with No. 1 valve at Murphy Dam at Pittsburg was made on December 9 and 10, 1970.

The repair of the valve to return it to an operating condition proved to be a simple one. It was found that setscrews had become loosen allowing a pin to drop out. The pin was located after the stilling pool was drained and was reinstalled with a minimum of effort.

The above work required draining of the various waterways, and during this time an inspection of the concrete, steel penstocks and valve operating mechanism was made. Our engineers have made certain recommendations as a result of this inspection and their report is attached to this letter for your consideration and files.

We are happy to have been able to work with you on this problem, and are also pleased that it proved to be not a too serious one.

Kind personal regards and best wishes for 1971.

Very truly yours,

H. E. Stockwell

H. E. STOCKWELL, DIRECTOR
HYDRO PRODUCTION

HES:fb
cc: R. A. Holden

[illegible] — January [illegible], 1971

[illegible] Brown

[illegible] - [illegible] DAM - [illegible]

A report on the same subject, dated December 22, 1970, addressed to you from G. D. Brown and R. H. Bloomfield covers the inspection of the waterways at Murphy Dam as well as repairs to the 12 Dow valve made on December 10, 1970.

Supplementing this report it would be well to recall the difficulty in operating the 24" penstock filler valve due to the extreme cold temperature and its effect on the lubricant in the gear cases of the gate stand. Some little time was consumed in acquiring a salamander to raise the temperature sufficiently to enable the gate to be operated.

Consideration should be given to the possibility of changing the present lubricant to one having a lower pour point.

CSB

CSB:tl

M E M O R A N D U M

DATE: March 21, 197[illegible]

FROM: Francis C. Moore, Water Resources Engineer

SUBJECT: Murphy Dam Control Gates - Pittsburgh

TO: Vernon A. Knowlton, Chief Engineer

"Stan" Brewer of N.E. Power called at 2 p.m. stating that the 30" venturi meter gate is operable. He says there are some stones in the outlet channel that may have come from riprap in the inlet channel.

Also, he thinks that the sleeves should be rebuilt and will write a report to the Water Resources Board on that and the fact that maybe the upstream trash rack below 1,330' elevation should be inspected for holes.

Also, the new parts to the large gate are rusting. Clesson will fix the small parts and N.E. Power Co. crew can cosmolene the large wrist pin when they repair the large venturi gates.

FCM:js

MEMORANDUM

TO H. E. Stockwell   COMPANY OR LOCATION   April 16, 1973

FROM C. S. Brewer   COMPANY OR LOCATION   FILE

SUBJECT MURPHY DAM - DOW VALVE INSPECTION AND REPAIR

Francis C. Moore, Water Resources Engineer for the State of New Hampshire requested by telephone March 14, 1973 that we investigate the reason the 30" Dow valve at Murphy Dam could not be opened. H. S. Bomhower and S. R. Lewis made a preliminary investigation March 15, 1973 and arranged to unwater the valves March 19, 20 to make repairs. The repairs were authorized by letter of March 19 from the Water Resources Board and executed on our work order #1145. The repair consisted of machining and installing a new pin for the lower end of the connecting rod. The old pin was salvaged but could not be re-used due to its poor condition from advanced corrosion.

During the two days of repair activity other conditions were noted which were brought to the attention of Francis Moore by telephone on March 21 with a promise of confirmation in writing after we had had an opportunity to consult with our engineering department. These conditions were:

1. There is about one third of the lead seal missing on the 30" valve. The position of the missing seal is from 4 o'clock to 12 o'clock looking upstream. The seal which is still intact is loose in many places. There is no repair we know of which we can guarantee and would recommend that present operating practices be reviewed with possible changes made to minimize cutting the body of the valve. Should a complete shut-off of water become desirable, consideration could be given to the installation of a second valve downstream of the existing one.

2. About 12" downstream of the seal of the 30" valve, two flat stones were found, 12" x 24" x 5" and 12" x 12" x 5" approximate dimensions. This recalled an incident of several years ago when it was impossible to close the valve and some damage to the floor stand was experienced. It is quite possible that one of these stones was under the seal at that time. The size of the stones would not permit their passage through the racks as built; so, it appears that there may be a hole in the racks or that these stones were inadvertently left in the tunnel at construction time and have been unobserved until now. In any case

B-25

it would seem that an inspection of the racks by diver would be in order.

3. The stainless steel sleeves which were applied to the connecting rods on both 84" valves in 1971 on our work order #7411 have failed in service. The sleeve from the #1 gate was found in two pieces on the floor of the stilling pool and the sleeve on the #2 gate, while still in place, revealed cracking of the seam welds. It is concluded that these failures were caused by a combination of the vibration encountered when passing water and the flexure taking place when the valve is tightly closed. Sleeving of the connecting rods is still considered the most economical method of extending the life of the connecting rods and the attached sketch illustrates the method recommended by the engineering department. The plug welds were not used in 1971 and it is expected that they will add enough extra strength to the sleeves to preclude their failure.

   Accompanying the sketch were the following instructions: "The tubing shall be split lengthwise and attached to the connecting rod by 14-3/4" diameter plug welds or stud welds as conditions warrant. The longitudinal splits shall be fully welding. The area on the connecting rod where stud or plug welds are located shall be ground to clean metal." In addition, the engineer granted that, if it would facilitate repair, the split welds could be made 90° to the location shown on the sketch and that mild steel plugs could be used if completely covered by stainless weld.

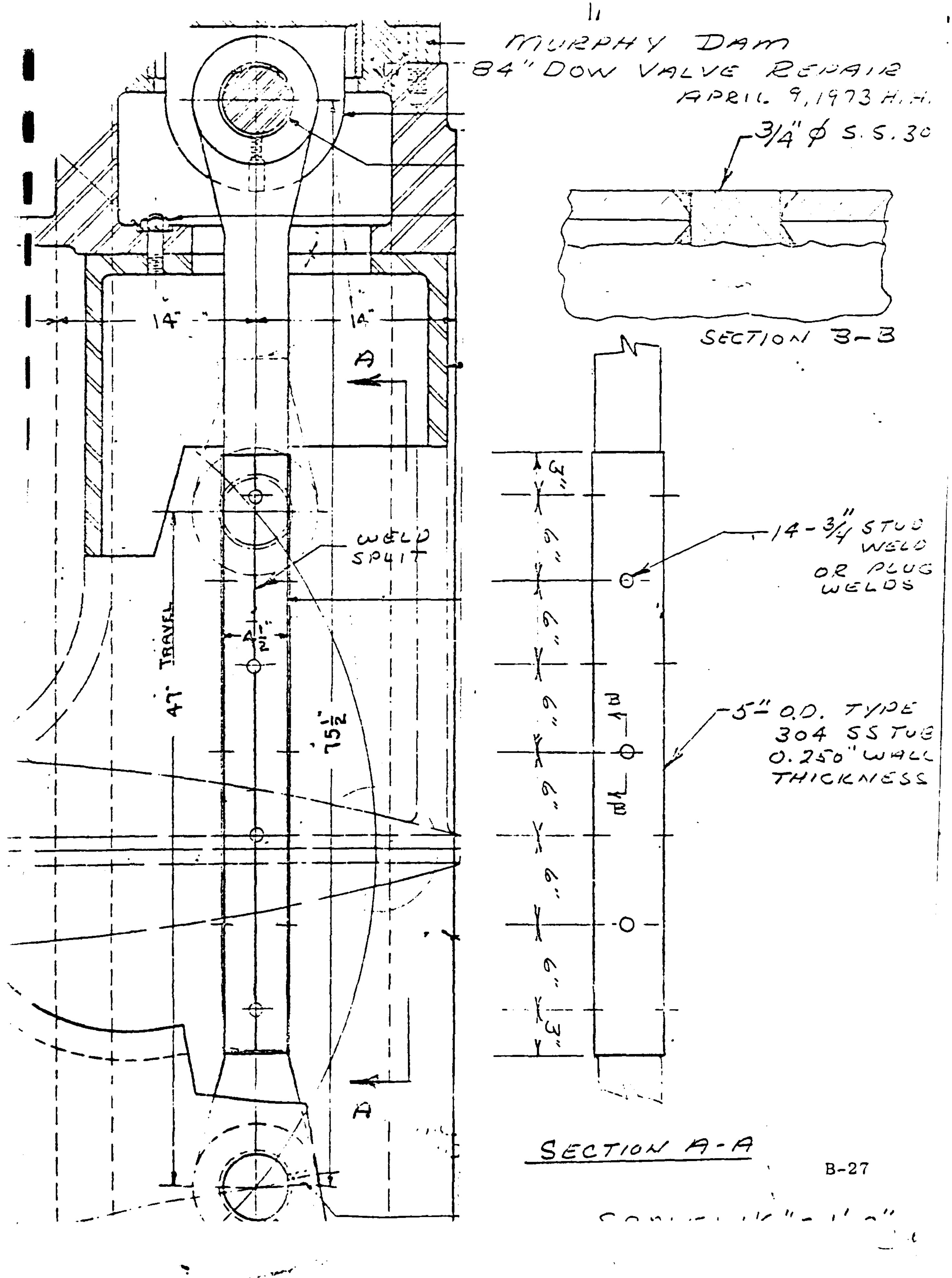
   It is estimated that the new sleeves could be purchased and installed for $2,000.

4. The new connecting rod and pins purchased in 1971 were examined and were found to have started rusting. These parts should be thoroughly cleaned and coated with grease to preserve their new condition until installed.

Should the Water Resources Board desire any assistance from us it would be desirable to be advised as soon as possible so that we could get it out of the way before our own heavy summer program of work commences.

CSB

CSB:tl
Att.
c/c - I. J. Trombley


MURPHY DAM
84" DOW VALVE REPAIR
APRIL 9, 1973 H.H.
3/4" ϕ S.S. 30
SECTION B-B
14"
14"
A
WELD
SPLIT
47" TRAVEL
75½"
A
3"
6"
6"
6"
6"
6"
6"
3"
14-3/4" STUD WELD OR PLUG WELDS
5" O.D. TYPE 304 SS TUBE 0.250" WALL THICKNESS
SECTION A-A

NEW ENGLAND POWER COMPANY 20 West Park Street, Lebanon, New Hampshire 03766
New England Electric System

April 20, 1973

Mr. George M. McGee, Sr., Chairman
Water Resources Board
State of New Hampshire
Concord, N.H. 03301

Dear George:

As you know, we have recently made some repairs to the 30" Dow valve at Murphy Dam. This work was requested of us by Francis Moore and was necessitated by the fact that the valve could not be operated.

After repair was made to the operating mechanism, further investigation revealed that the lead seal of the valve is in very poor condition with approximately one-third of the seal actually missing. Due to inaccessibility and limited working space, there seems to be no way that repairs can readily be made.

It was also noted that there are two large stones downstream of the valve which could have come through the rack sections and passed on through the valve. If they did come through the racks and on through the valve it is quite possible that they could be responsible for some of the damage. This raises the question of the possible need of a general inspection of the racks by a diver.

While the head gates were lowered for the work on the 30" valve an inspection was made of the repair work done on the 84" valve in 1971. It was discovered that this repair work is beginning to fail. Our engineers have commented on this and have come up with possible ways of making new repairs to the operating mechanism which would be more satisfactory.

A very complete report on these problems has been prepared by our Mr. C. S. Brewer and a copy is attached for your use. If we can be of any further assistance, please advise us. In case you do wish us to do more work, it would be a help to us if this determination could be made soon as our summer maintenance work load will be heavy this year.

Kind personal regards.

Sincerely,

H. E. Stockwell

H. E. STOCKWELL, DIRECTOR
HYDRO PRODUCTION

HES:tl
Att.

c/c - F. R. Joslin
J. Trombley

NEW ENGLAND POWER COMPANY 20 West Park Street, Lebanon, New Hampshire 03766

New England Electric System

January 8, 1974

Mr. Peter Merkes
Water Resources Board
State of New Hampshire
37 Pleasant St.
Concord, N.H. 03301

Dear Mr. Merkes:

Between the dates of November 9 and November 12, 1973 a three man crew from our Comerford Station made repairs to the two 84" valves at Murphy Dam as requested in your letter of June 1, 1973.

A new split stainless steel sleeve 3' long was installed on the gate lever of the west valve and attached to the lever by 10-plug welds. Both splits of the sleeve were welded their entire length. Although a new stainless sleeve had been prepared for the east gate it was not necessary to use it and it was left at the gate house. The sleeve which had been installed on the lever of the east valve in 1971 was salvaged by welding its two seams where they had cracked and by plug welding the sleeve to the lever as in the case of the west valve.

The wrist pins on both valves were again found loose due to loosening of the set-screws. The pins were secured by welding a 2½" x 3/8" flat bar to the disc over the end of each pin to prevent its backing out.

Pitting continues on both deflectors and consideration should be given to surfacing the pitted areas with stainless weld at sometime in the future.

Very truly yours,

C. S. Brewer

C. S. BREWER
SUPT. OF MAINTENANCE

CSB:tl
c/c - I. J. Trombley
H. H. Bloomfield

NEW ENGLAND POWER COMPANY

New England Electric System

9 Court Street, Lebanon, New Hampshire 03766

October 18, 1974

Mr. Vernon Knowlton
New Hampshire Water Resources Board
31 Pleasant St.
Concord, N. H. 03301

Dear Mr. Knowlton:

On October 9, 1974 an inspection party composed of people from New Hampshire Water Resources Board and New England Power Company made an inspection of Murphy Dam in Pittsburg, New Hampshire.

For your records we attach a copy of a report of that inspection issued by Mr. Denton E. Nichols of Westboro.

Very truly yours,

H. E. Stockwell

H. E. STOCKWELL, DIRECTOR
HYDRO PRODUCTION

HES:fb
Enc.

MEMORANDUM

LDPierce — COMPANY OR LOCATION — 11 October 1974

DENichols — COMPANY OR LOCATION — FILE

INSPECTION OF MURPHY DAM, SPILLWAY AND CONTROL HOUSE

On 9 October 1974, an inspection was made of Murphy Dam, spillway and control house with personnel from the New Hampshire Water Resources Board. The reservoir elevation was 1378.3 and the discharge was 600 c.f.s. The inspection was made by the following personnel:

Francis Moore. . . . . New Hampshire Water Resources Board
Donald Raposa. . . . . New Hampshire Water Resources Board
David Chapel . . . . . Murphy Dam Attendant
Charles Harrington . . New England Power Company, Lebanon
Denton Nichols . . . . New England Power Service Company, Westboro

DAM AND INTAKE STRUCTURE

The appearance of the embankment, upstream face and intake structure was good; however, the dam is becoming overgrown with brush and trees up to 15 feet tall on the upstream and downstream slopes. The structural condition of the gatehouse was very good, with no spalling of concrete and the brick pointing was sound. The building exterior flashing and roof is in good condition. There was some minor spalling of the gatehouse walkway concrete at the gatehouse end.

The downstream toe of the dam was inspected and there was no apparent seepage along the maximum section. There is a low area on top of the penstock between the toe and control house which is trapping water. The shallow 'V' ditch towards the south is not draining the low area adequately into and through the brush and wooded section. The three inch riser pipe driven into the old stream bed is barely visible because of flooding from a nearby beaver dam. It couldn't be determined if it was discharging any water as reported in 1964.

SPILLWAY AREA

In general, the spillway area concrete was good with three exceptions: The top corner of the access stairs has deteriorated and undercut the handrail post; the second and fourth bay concrete beams have spalled along the edges with some reinforcing steel exposed; the toe of the first pier is spalled three and five feet above the ogee. Shearing between the bridge beams and piers continues with spalling in this area on the second and fourth piers and some reinforcing steel exposed on No. 2 pier's north side. No. 4 pier has been replaced since the 1964 inspection and no cracking was noted. The flashboard ogee concrete was sound and, the north and south abutment walls are in very good condition. The caulking used between the bridge beam joints has deteriorated. The top two flashboards are rotting.

The stanchion beams are rusting along the webs above the stop logs and all around the tripping mechanism. Of the 21 stanchions, there are 14 which are missing the locking bar, rod and nut at the trip mechanism. The stop logs appeared to be sound and in good condition.

LDPierce
Page Two
11 October 1974

Leakage from the bedrock below the concrete apron and through the south abutment wall drain holes was the same as viewed in previous inspections. The spillway channel conditions are the same; however, there is some scattered brush growing in the channel and a substantial growth along the top of the channel walls. Some medium sized rock chunks have fallen into the channel above the roadway access bridge.

The walkway steel grating to the north abutment is loose in several places and is rusting badly. The security gate at the end of the walkway has been damaged at opposite corners and is badly racked.

CONTROL HOUSE AREA

The control house brick exterior is cracking on all four walls at each corner, with the northwest and southeast corners more advanced. There, also, is water entering the control house east and west walls at the brick contact with the granite sill, as evidenced on the inside by water stains on the floor. There are five asbestos shingles missing from the north and west roof slopes.

The beam over the outlet structure has developed a crack along its southern third and the edges are spalling. Hairline cracks also appear at each end of the same beam higher up.

The first vertical joint in the right hand retaining wall below the outlet has developed moderate spalling along its edges. This is in the stilling basin area.

Inside the control house the venturi gate stand is still raised off its base plate with the anchor bolt nuts still loose. The anchor bolts appear to be solid. The same condition exists as in 1964.

GENERAL

The spare operator arm and deflector stored in the gate house are rusting and should be protected with a rust preventative. The spillway gate board on the upstream retaining wall has rusted and is extremely difficult to read.

RECOMMENDATIONS

As a result of the inspection, it is suggested that the following work be accomplished to maintain and improve the various problems:

1. Cut the brush and trees on the upstream and downstream slopes of the dam and along the spillway channel walls. A periodic program of brush control by spraying and cutting should be established in the future to avoid the extensive work needed now.

LDPierce
Page Three
11 October 1974

---

2. The stanchion beams in the spillway should be scraped, primed and painted. The spare set of beams should be scraped and painted. These beams could then be used in a stanchion bay and the removed beams scraped and painted until all bays are done. Replacement of the 14 locking bars, rods and nuts on the stanchions should be accomplished.

3. The stairway concrete and bridge beam concrete should be chipped down to sound concrete exposing the reinforcing steel, then poured to the original grade. The construction joints between the beams should be cleaned out and filled with a mastic, such as Colma-joint sealer by SIKA.

4. The flashboards are deteriorating and should be replaced. The steel grating walkway over the flashboards should be scraped and painted and anchored securely in several areas. The spillway gage board should be cleaned and painted.

5. The ditch at the toe of the dam that drains south from the penstock low area should be regraded into the wooded area to improve the drainage flow from the penstock. The beaver dam should be breached to drain the flooded riser pipe and a measurement in g.p.m. obtained from the riser if available.

6. Consideration should be given to caulking the corner wall cracks in the control house and along the sills to prevent moisture and water from entering and causing further deterioration. The five missing asbestos roof shingles should be replaced.

7. The venturi gate stand should be shimmed and the anchor bolt nuts tightened to prevent the stand from movement during gate operation in the future.

D. Eliceholson

DEN:cfc

Copies: DRCampbell
CMHarrington
HEStockwell

October 15, 1976

Mr. Hugh Sullivan
New England Power Company
20 West Park Street
Lebanon, N. H.

Dear Mr. Sullivan:

Enclosed please find a copy of the recent inspection conducted at Murphy Dam. Also enclosed find calling card of the company which conducted the inspection - Diablo Divers.

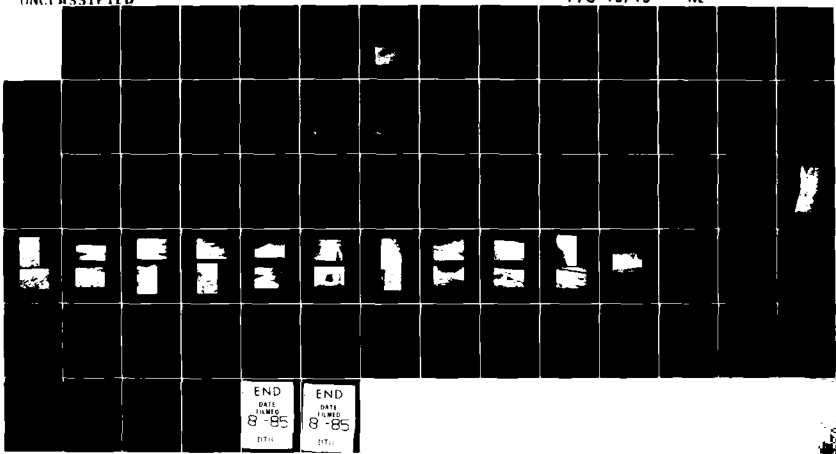
Sincerely,

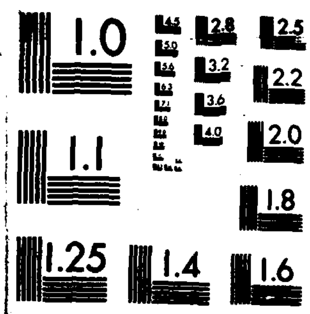
Zoes J. Dimos
Engineer

ZJD:L
Att.

AD A156 532 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS MURPHY DAM (NH 00185)..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 81 2/2

UNCLASSIFIED F/G 13/13 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

M E M O

From: Zoes Dimos October 14, 1976

To: Vernon Knowlton, Chief Engineer

RE. INSPECTION OF MURPHY DAM INTAKE STRUCTURE

On October 11, 1976, we arrived at Pittsburg for the inspection of the intake structure. Personnel present were: Zoes Dimos and Dave Chappel of N. H. W. R. B.; Bill Nau, Dick Marshall and Dr. Bruce Gauf all of the Diablo Diving Company, Portsmouth, N.H.

On October 11th at approx. 10:00 P.M. the first dive was made. During this dive the gate guides and seats were inspected. Bill Nau reported that the guid es and seat are in very good condition. The only deterioration noted was that on the steel ladder rungs. It was during this dive that the diving team set up their lines for their entrance into the tunnel.

On October 12th, 1976, at approx. 11:00 A.M. the second dive was made. Bill Nau and Dick Marshall inspected the tunnel and the trash racks. They reported that:

(1) The intake structure seems to be in good condition with no major visible cracks, no deterioration of the joints, and no signs of spalling.

(2) There were no large boulders found in the intake.

(3) The trash rack is in good condition. The bar spacings on the trash rack are 6.5" c to c with 1.5" thick steel bars as Bill reported. Bill also reported that the bars show signs of rust just on their southerly side, however, it is not excessive. He also reported that there does not exist any bulking head problems with the trash racks. The only obstructions in front of the racks

were three eight-inch diameter by roughly four feet long logs.

It should also be noted that during this inspection the head gate was left open, the butterfly valves were closed, and the fish flow was passed through the stoplog section.

Zoes J. Dimos
Engineer

ZD:L

cc: Mr. Hugh Sullivan
N. E. Power Co.
Lebanon, N.H.

M E M O R A N D U M

DATE: October 24, 1974

FROM: Francis C. Moore and Donald M. Rapoza, Engineers

SUBJECT: Murphy Dam Inspection - #194.12 - Pittsburg

TO: Vernon A. Knowlton, Chief Water Resources Engineer

On October 9 and 10, 1974, (Wednesday and Thursday), Francis C. Moore and Donald M. Rapoza inspected Murphy Dam in Pittsburg in company with New England Power Company Engineers Charles Harrington and Denton Nichols. This inspection covered the dam, spillway, intake and control houses, highway bridge, outlet channels, etc. New England Power Company report accompanies this memorandum and is concurred with, except that under intake structure, the minor spalling of concrete was on the outside concrete band at and just below the floor level of the intake house on the front (or door) side, not on the gatehouse walkway concrete. During the most of this inspection, Dam Operator David Chappell accompanied us.

Detailed findings are:

GATE HOUSE:

1. The gasoline motor used to hoist the gate needs all hose connections replaced as they look porous.

2. Change the grease in the small gate house equipment as it required heat to operate in the winter of 1972-73. N.E. Power Company can recommend the grade needed.

3. BIF spare operator arm and deflector is rusting considerably. Rust preventative and preservative should cover the parts to further rust.

4. Some panes of glass in windows are cracked.

5. There is a small corner crack in the brickwork left of door which needs mortaring.

CONTROL HOUSE:

1. Water leaks inside from east and west walls on first floor. This could be corrected by pointing up concrete cracks and Thorosealing joints.

2. Flashing at roof should be checked for leakage, including around chimney and eaves.

3. Five asbestos shingles are missing on roof.

4. Cracks are developing in outside brickwork near all four corners that should be sealed to prevent entrance of moisture.

5. Granite band just below first floor level has cracked in several places and spalled off in one place.

6. Window beside cellar stairway has caulking below window missing and/or cracked. This has caused some leakage inside.

7. West side roof gutter has a broken joint (copper gutter).

8. Examine asbestos shingles to see that they are in good condition.

9. Small venturi gate is lifted. This should be repaired to prevent looseness.

10. In windows, 18 panes are cracked.

11. Check for leakage into and behind fire brick from roof near eaves. This may cause the cracking of exterior brick noted under #4 above.

12. Beam over the outlet structure has a crack which is leaking water. Source of this moisture, ground water or otherwise, should be determined.

STILLING BASIN:

1. Joints in side walls are spalling moderately.

2. South side of concrete retaining wall along stilling basin should have settlement holes filled and the adjacent area regraded to top of concrete retaining wall.

PENSTOCK FROM GATE TO CONTROL HOUSE

Should open up a ditch from the low wet spot over penstock south parallel with toe of dam to drain the area - at least 1% grade This should carry a ditch into woods which should be cleared, vegetated and kept mowed. The new ditch should be inspected at least annually. (See attached profile and sketch.)

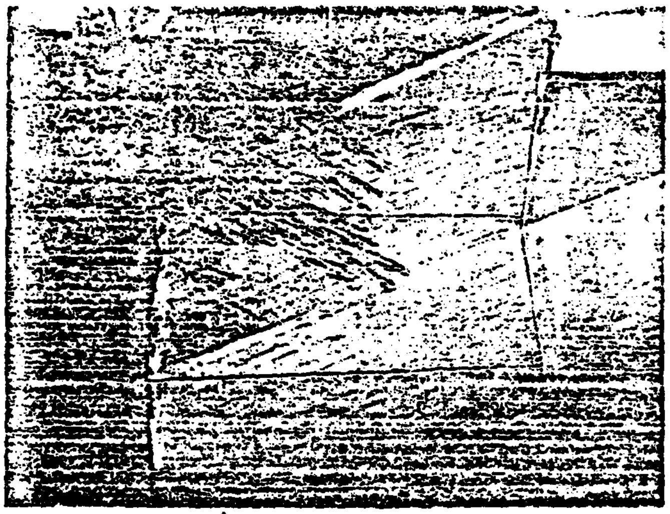
OBSERVATION WELL

Have beaver dam removed, then check well for flow and siltation periodically.

HIGHWAY BRIDGE

1. Reinforced concrete is exposed in at least one spot on bridge roadway. Suggest asphalt paving of roadway to seal concrete.

2. Minor spalling of concrete joints downstream with abutment as shown in attached photo. (see next page.)

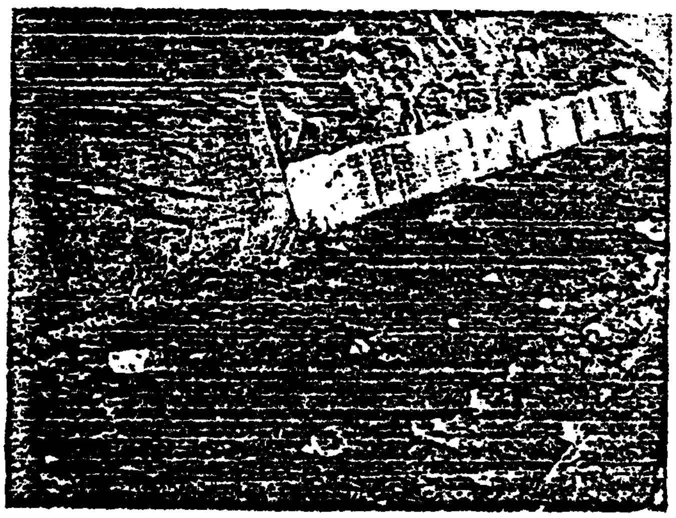


Highway Bridge to control house over spillway outlet channel. Shows downstream north abutment spalling.

SPILLWAY CHANNEL

1. Weep holes in abutment wall near stairway to spillway catwalk should be checked periodically for variations in flow and to see if water carries any silt.

2. Some spalling at joints in abutment walls but not as yet serious. (See photo.)



Murphy Dam spillway channel - North retaining wall showing degree of spalling of concrete.

3. Trees and brush in back of abutment walls along spillway channel should be cut and sprayed periodically to prevent regrowth. This should be cleared at least 10 feet from top of concrete wall.

4. Growth and spalled rocks, old stoplogs from stanchions in spillway outlet channel should be removed.

NORTH SPILLWAY CHANNEL DIKE & WEST SPILLWAY DIKES

1. Clear both slopes of dikes of all trees and brush.

2. Maintain grass slopes to dikes.

TURNER DIKE (Along US Rt. #3)

This dike has side slopes maintained free of trees and brush by N.H. Dept. of Public Works & Highways.

DAM EMBANKMENT

1. Brush should be sprayed every other year and initially large trees cut and removed on both up and downstream slopes.

2. Large logs on upstream slope should be removed to prevent rotting and furnishing nourishment to future growth.

3. A strip of open grass should extend along the toe of dam embankment at least 20 and preferably 30 feet wide for inspection of seepage, etc. South half of toe is now forested.

4. Depression at downstream toe of embankment appears to be settlement over rocky fill or spoil area. Further investigation of holes (up to 8 feet deep) should be made using a backhoe. There is apparently no seepage reaching surface at time of inspection.

5. Observation well in old filled-in river channel is flooded by a beaver dam pond. Suggest having beaver dam breached and beavers removed so that flow and possible sediment from well can be determined. This should be done at least annually.

ROADWAYS

Scouring and "pot" holes should be filled and compacted. Possibly consideration to surface treat roads with asphalt should be given.

SPILLWAY

1. Steel bridge over flashboard spillway should have clips installed on floor grating to hold in place. Vandals have thrown down and bent two panels which have been retrieved and straightened.

2. Gate at north end of bridge has diagonal corners badly cracked causing serious sagging of gate. New 2 new corner pieces installed.

3. All steel work on bridge should be chipped or sandblasted, sealed and painted.

4. Concrete catwalk over spillway needs considerable chipping and sealing of concrete along downstream edge and a little on upstream edge. Steel reinforcing is exposed in one place.

5. Joints over 1st and 2nd piers have sealer pushed up and are cracked so that water can be admitted to joint. Need resealing.

6. Whole catwalk should be Thorosealed to retard deterioration.

7. Stairway to catwalk needs to be chipped to sound concrete, then patched and Thorosealed. There is extensive spalling in this area including under one railing post.

8. All railings should be chipped, sealed and repainted.

9. Bottom rail in one section near top of stairway to catwalk is missing and should be replaced.

10. Concrete on first pier from stairway, south side, has water leaking from a crack about 5 feet up from bottom about two feet downstream of stoplog. This should be repaired by "dental" work new concrete.

11. Flashboards should be all renewed.

12. Fourteen locking bars on trip mechanism of 21 stanchions are not in place. Some are missing, others are in dam operators garage. All these should be replaced as soon as possible due to chance that vandals could trip stanchions.

13. Stanchion steel needs sandblasting or chipping, sealing and painting. As there is one extra set of shallow bay stanchions, they should be fixed and used while that bay is being retreated.

14. Wood strips on stanchions should be replaced with new, treated wood strips. These strips act as guides to stoplogs and also are placed on piers as guides.

15. Pie-shaped fillets above locking bars on trip mechanism are rotten and all 21 need replacing.

fcm/js

MEMO

TO: Vernon A. Knowlton, Chief Engineer

FROM: Zoes Dimos, Water Resources Engineer

SUBJECT: Murphy Dam Repairs

DATE: March 7, 1978

1. Slope area upstream of east spillway dike should be cleared.
2. Area between the right spillway discharge channel should be cleared.
3. Eroded concrete on the service bridge deck to be repaired.
4. Drain spillway discharge channel stilling basin pool just downstream of service bridge to inspect foundation of retaining walls.
5. Clear all growth on dam and dikes.
6. Repair entrance gate at spillway section.

ZD:njk

OPERATION PROCEDURE FOR PITTSBURG RESERVOIR DURING PERIOD OF HIGH INFLOW TO BE FOLLOWED BY OPERATOR IF COMMUNICATION WITH ADVISERS IS NOT POSSIBLE

PAGE 1

GENERAL COMMENTS

When pond elevation is constant, inflow equals outflow.

When pond elevation rises, inflow exceeds outflow.

When pond elevaton falls, outflow exceeds inflow.

During periods of rising inflow the outflow must not exceed inflow. In other words, the pond elevation must not be allowed to drop during the periods of rising inflow.

When there is any discharge at the spillway, the gage at that location does not give a true indication of pond level. Therefore, the gage at the outside of the gate tower should be the measure of pond elevation and record at all times.

When the valve discharge exceeds the registration of the Venturi meter capacity of 2,000 c.f.s., the discharge can be determined by differences between the manometer reading at the venturi entrance: and first, the elevation on the gate house tape gage; second, the elevation of the pond staff gage; third, the pond elevation as determined by the manometer reading. If the racks at the tunnel intake become partially plugged with debris, the drop in pressure between the pond and any point below the racks will be increased abnormally, and consequently the difference in elevation between the pond and the venturi entrance will not be a reliable measure of the discharge through the tunnel. Therefore, the difference in elevation between the gate house tape gage and the venturi entrance should be used to determine discharges, if there is any chance that the racks have collected debris.

The relations of upper gage readings to the venturi entrance readings are given in the first sentence of the above paragraph in the order of their reliability and desirability. If time permits, it is desirable to check each staff gage reading on the pond gage outside of the gate tower by a manometer reading.

Whenever pond elevation and pond inflow conditions are such that the manometer system is liable to be used for measuring valve discharge, the air should be purged from the system once a day or oftener if necessary, and check determinations of the discharge as measured by the manometer, according to instructions in the second preceding paragraph, compared to discharge indicated by the venturi meter should also be made while the venturi meter readings are below 2,000 cubic feet per second and still reliable. (See diagram and instructions in the use of the manometer to determine valve discharges.)

Readings of pond elevation on the gage outside the gate tower and elevation of the water at the float gage inside the tower and also readings of elevation at the venturi entrance should be made and recorded half hourly, if personnel is available, otherwise hourly, during periods of high discharge.

The time of all gate changes, flashboard pin failures and replacements should be recorded accurately. Careful notes should also be recorded describing the nature and extent of any obstructions such as ice, driftwood, pulpwood and driki which may hinder the passage of water through the needle beam bays and over the open spillway flashboards or crest.

This procedure is subject to change without notice and is not to supplement oral or written orders from proper authorities when available.

PROCEDURE DURING RISING INFLOW

With a pond elevation below 1385.0 and a rising inflow, normal operational storage releases may be continued with no limitations on the amount of discharge except as governed by downstream stage heights and being careful never to exceed the inflow during a rising stage, i.e. elevation of pond holds or continues rising.

PAGE 2

ALERT

a. As the water elevation approaches 1385.0 the operator should be alert and secure information as to weather predictions and elevations at First and Second Lakes, as well as the possible discharge, if any, from First Lake.

CLOSE VALVES

b. If water in the reservoir reaches elevation 1385.0, close the control valves, thus ponding all inflow.

POND ELEVATION RISES. FIRST HALF NO. 5 BAY BOARDS GO OFF

c. As the water elevation reaches 1387.0 with indications of continued rise, open control valve to discharge 100 c.f.s. for every 0.1 foot rise in the elevation of the pond to the elevation of the first board failure on one half of Bay No. 5. This failure should occur at about water elevation 1387.6, at which time the discharge before failure will be:

Spillway 2,000 c.f.s., plus valve 600 c.f.s. = 2,600 c.f.s.

CLOSE VALVE

d. When board failure occurs, close valve tight.

POND ELEVATION RISES. SECOND HALF NO. 5 BAY BOARDS GO OFF

e. If pond continues to show a tendency to rise, open control valve to discharge 100 c.f.s. for every 0.1 foot rise in the elevation of the pond to the elevation of the second board failure on the remaining one half of Bay No. 5. This failure should occur at about water elevation 1388.1, at which time the discharge will be:

Spillway 3,550 c.f.s. plus valve 500 c.f.s. = 4,050 c.f.s.

CLOSE VALVE

f. When board failure occurs close valve tight.

POND ELEVATION RISES TO 1388.5. POND LEVEL CONTROL BY VALVES

g. After the second half of Bay No. 5 flashboards have gone off, if the inflow exceeds the outflow and the pond elevation continues to rise, make no move to control the elevation until the pond has reached elevation 1388.5. Control the pond at this elevation by opening the control valves to a maximum discharge of 2,000 c.f.s.

POND LEVEL CONTROL BY TRIPPING NEEDLE BEAMS

h. If in spite of all discharge already made available the pond reaches elevation 1389.0, control the pond at this elevation by tripping first the short needle beams (Bays 2, 3 and 4) and then the long needle beams (Bay 1) as necessary to keep the pond elevation from exceeding elevation 1390.0. After each beam has been tripped, a short time should elapse during which time the pond level gage should be watched to determine the trend.

PROCEDURE DURING FALLING INFLOW

After the peak inflow in any high water period there will be a recession or diminishing inflow period. The operator should proceed as outlined below under condition A or B, whichever situation exists at the time the following prevails:

CONDITIONS INDICATING RECESSION HAVE BEGUN

1. The recession period has evidenced itself by a drop in the lake level of 0.2 of a foot.

2. Weather conditions indicate a continuing decrease in runoff.

3. Communication with advisers is impossible.

CONDITION A

HOLD POND LEVEL WITH VALVE CONTROL

Pond level is below 1389.0 and no stanchions have been released.

1. Hold pond level if possible by closing valves if the recession period began with valves discharging.

the inflow ... continues rising.

PAGE 3

2. Following closure of the valves, the discharge will gradually diminish as the pond level falls.

3. When the discharge through the spillway has reduced to 2,000 c.f.s. and if down river stages and plant requirements permit it, the discharge should be held at 2,000 c.f.s. with valves and spillway limiting maximum valve discharge to 1,500 c.f.s. until pond elevation reaches 1383.0. If the discharge has peaked below 2,000 c.f.s., hold that particular discharge or such discharge as the down river stage will permit limiting valve discharge to 1,500 c.f.s. until the pond has been drawn to elevation 1383.0.

CONTROL DISCHARGE AT 2,000 C.F.S.

4. Pins and boards can now be replaced on Bay No. 5 and normal operational storage releases can proceed.

REPLACE PIN BOARDS

CONDITION B

Pond level is at or above elevation 1389.0 and stanchion releases have been made.

1. Hold pond level if possible by closing valves which, under this condition, will be discharging 2,000 c.f.s. at start of recession.

HOLD POND LEVEL WITH VALVE CONTROL

2. Following closure of valves, the discharge will gradually diminish as the pond level falls.

3. When the discharge through the spillway has reduced to 2,000 c.f.s. and if downriver stages and plant requirements permit it, the discharge should be held at 2,000 c.f.s. with valves and spillway limiting maximum valve discharge to 1,500 c.f.s. until pond elevation reaches a point where replacement of needle beams and stop logs are possible. This elevation will be considerably below 1385, probably.

CONTROL DISCHARGE AT 2,000 C.F.S.

4. Following replacement of all needle beams and stop logs to original elevation if the discharge is such that it can be controlled by a maximum valve release of 1,500 c.f.s., replacement of the pins and flashboards on Bay No. 5 can be made.

REPLACE NEEDLE BEAMS AND STOP LOGS

5. Following replacement of the boards in No. 5 Bay, close valves and allow pond to fill to 1385.0.

ALLOW POND TO FILL

6. Normal operation can now proceed.

SPECIAL NOTES REGARDING REPLACEMENTS

Flashboards supported by pipe pins on the open spillway (Bay No. 5) should never be partially removed. If any are removed, all should be removed down to the concrete spillway crest.

Careful watch and consideration should be given to weather, river and runoff conditions and discharge program at reservoirs above during the entire period during which flashboard replacement is proceeding. Anything which causes the pond level to rise would of course return the activities to a rising flow procedure.

Any development which tends to increase the inflow into the pond should be carefully considered and decision made as to whether such development is reason for a temporary stoppage of replacement of boards, needle beams and stop logs or even a return to the procedure for a rising pond.

NEW HAMPSHIRE WATER RESOURCES BOARD APRIL

5M—7-59
39437

NEW HAMPSHIRE WATER RESOURCES BOARD

PITTSBURG DAM-OPERATING RECORD TO 7:00 A. M. EST-EDST

7:00 A. M. READINGS

WATER ELEVATIONS

GATE TOWER - OUTSIDE .... FT.
GATE TOWER - INSIDE .... FT.
HEAD LOSS .... FT.
LAKE ELEVATION .... FT.
INTAKE GAGE .... FT.
SPILLWAY GAGE .... FT.
MANOMETER .... FT.
DISCHARGE CHANNEL GAGE .... FT.

DISCHARGE

LARGE VENTURI .... CFS
SMALL VENTURI .... CFS
SPILLWAY (TOTAL) .... CFS
TOTAL DISCHARGE .... CFS

FLASHBOARD ELEVATIONS

NO. 1 BAY (CR. 1370) ....
NO. 2 BAY (CR. 1375) ....
NO. 3 BAY (CR. 1375) ....
NO. 4 BAY (CR. 1375) ....
NO. 5 BAY (CR. 1383) ....

VALVE SETTINGS

NO. 1 (84-INCH) ....
NO. 2 (84-INCH) ....
NO. 3 (30-INCH) ....

PRECIP. TO 7 A. M. .... INCHES
TEMP.: MAX. .... MIN. .... 7 A. M. ....
WEATHER .... WIND ....

CHANGES IN VALVE SETTINGS

TIME	VALVE NO.	INDICATOR BEFORE	INDICATOR AFTER	CFS DISCHARGE BEFORE	CFS DISCHARGE AFTER	TOTALIZER READING-CU. FT.

CHANGES IN FLASHBOARDS

TIME	BAY NO.	REMOVED INCHES	ADDED INCHES	HEIGHT OF BOARDS-FT. BEFORE	HEIGHT OF BOARDS-FT. AFTER	SPILLWAY GAGE ELEVATION

CONN. R. BELOW INDIAN ST.: EL.: .... TIME: .... A. M. / P. M.

REMARKS AND MISC.

.... OBSERVER

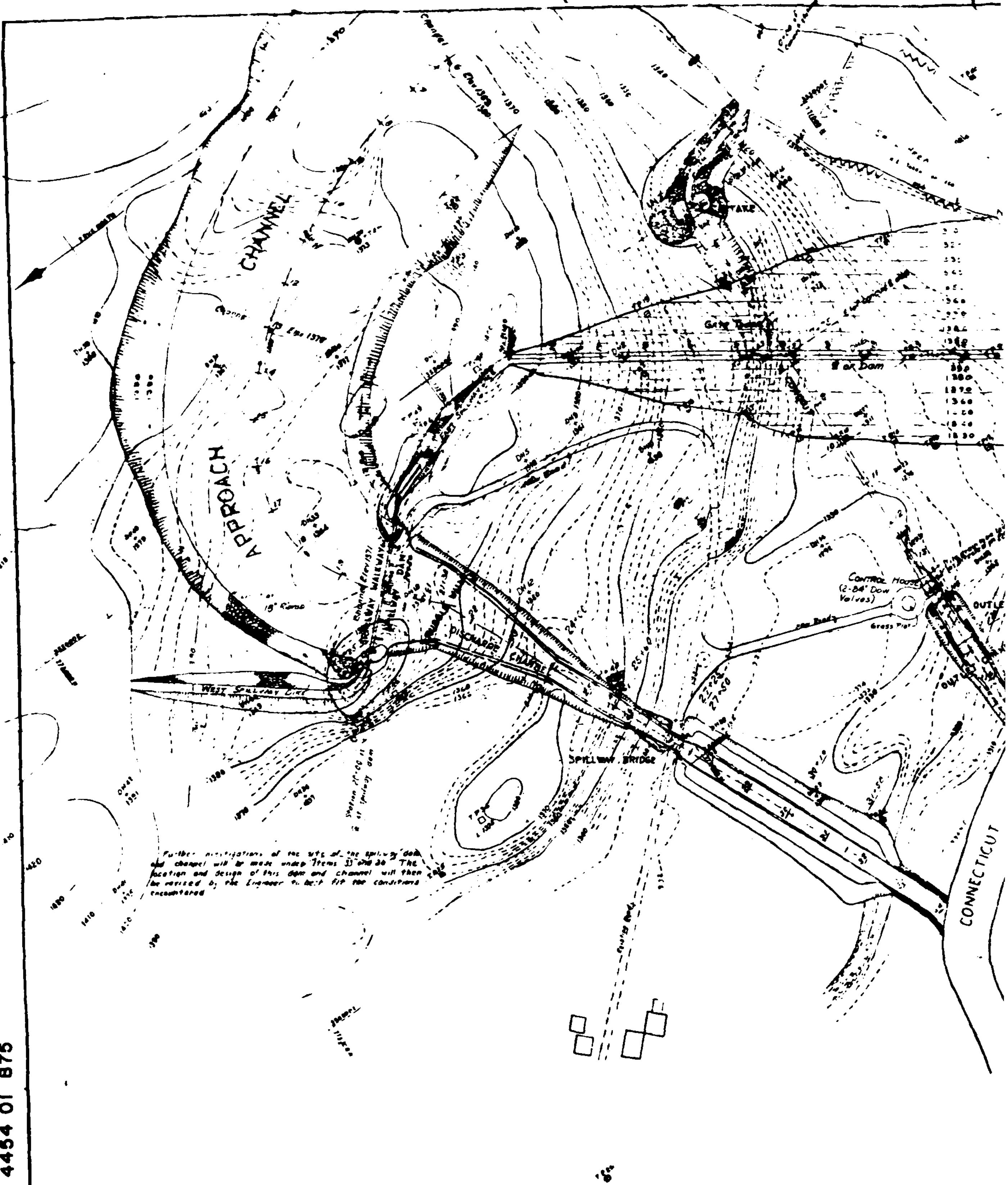
24 HOUR DISCHARGE AND FLOW

LARGE VENTURI READING
7 A. M. TODAY ....
7 A. M. YESTERDAY ....
24 HR. DISCHARGE (CU. FT.) ....
SMALL VENTURI READING
7 A. M. TODAY ....
7 A. M. YESTERDAY ....
24 HR. DISCHARGE (CU. FT.) ....
TOTAL VENTURI DISCHARGE (CU. FT.) ....

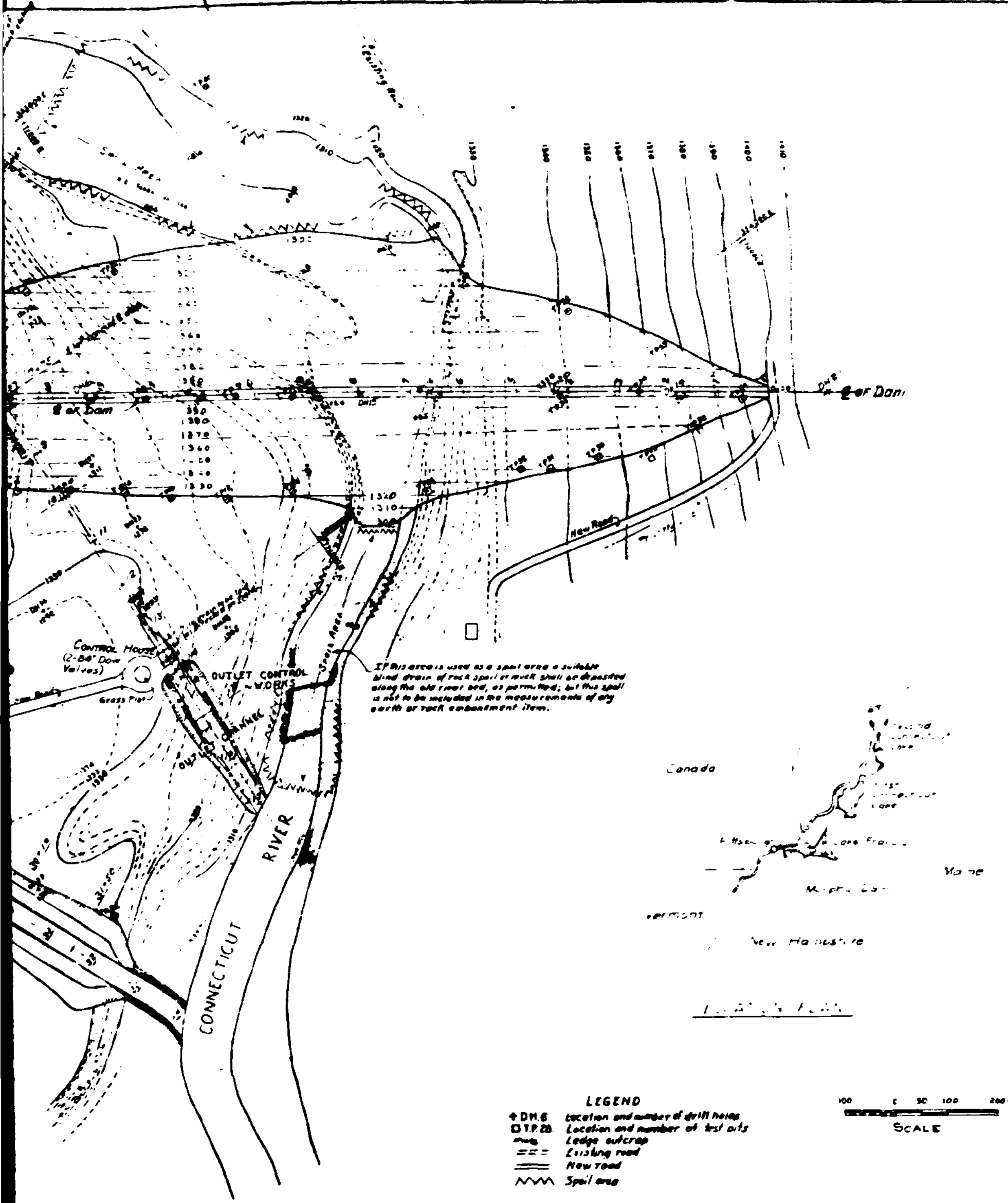
COMPUTATIONS

TOTAL DISCHARGE
TOTAL VENTURI .... C. F. S. H.
NO. 1 BAY .... C. F. S. H.
NO. 2 BAY .... C. F. S. H.
NO. 3 BAY .... C. F. S. H.
NO. 4 BAY .... C. F. S. H.
NO. 5 BAY .... C. F. S. H.
TOTAL DISCHARGE .... C. F. S. H.
RESERVOIR CONTENTS
7 A. M. YESTERDAY .... C. F. S. H.
7 A. M. TODAY .... C. F. S. H.
CHANGE (±C. F. S. H.) .... C. F. S. H.
TOTAL INFLOW .... C. F. S. H.
PAST 24 HOURS
AV. DISCHARGE .... C. F. S.
AV. INFLOW .... C. F. S.
MONTH TO DATE
TOTAL DISCHARGE .... C. F. S. H.
TOTAL INFLOW .... C. F. S. H.
.... COMPUTER

DAY .... DATE .... 19......



FILE NO. 4454 01 B75

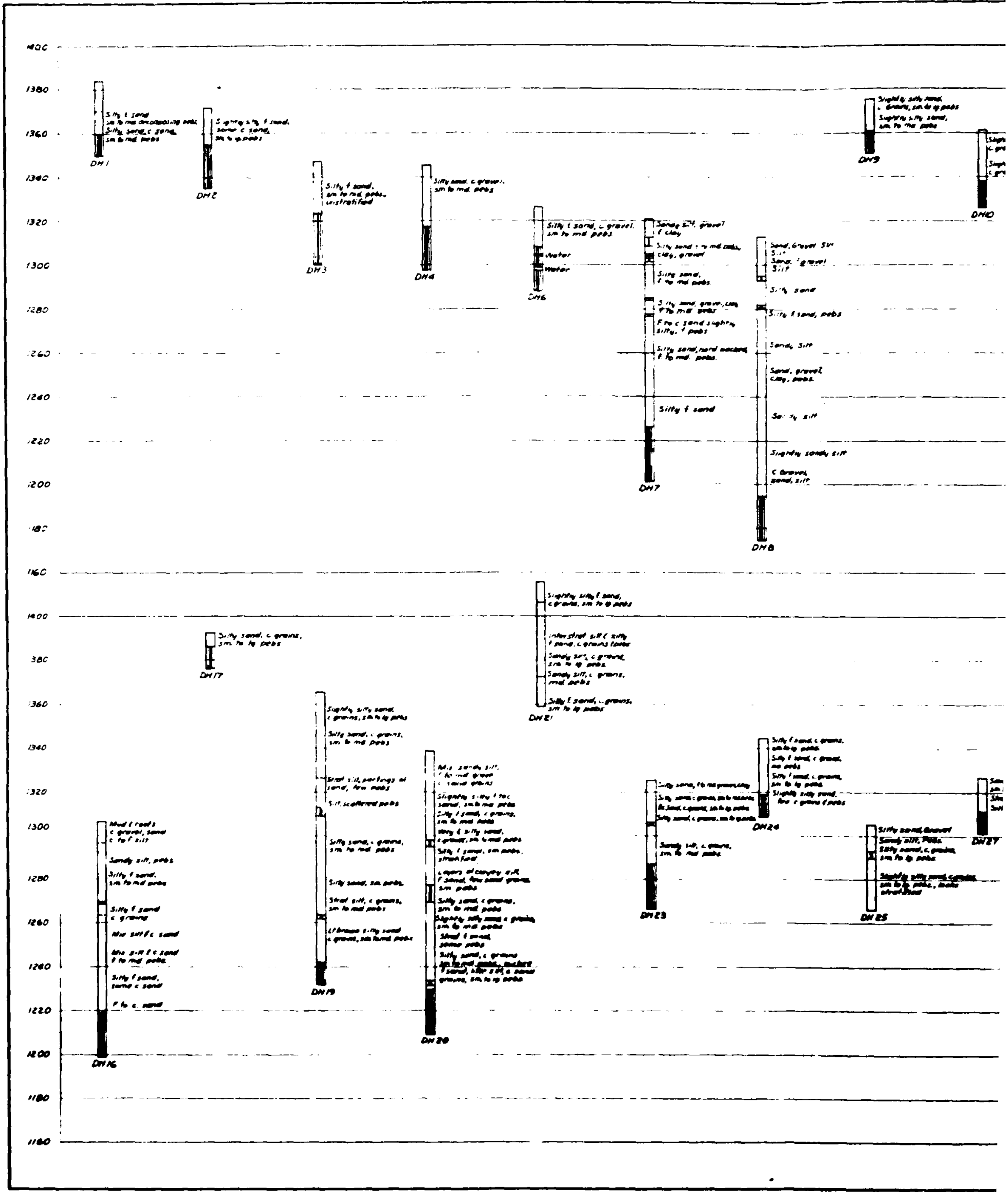


NEW HAMPSHIRE WATER RESOURCES BOARD
Concord N.H.
PITTSBURG RESERVOIR DAM

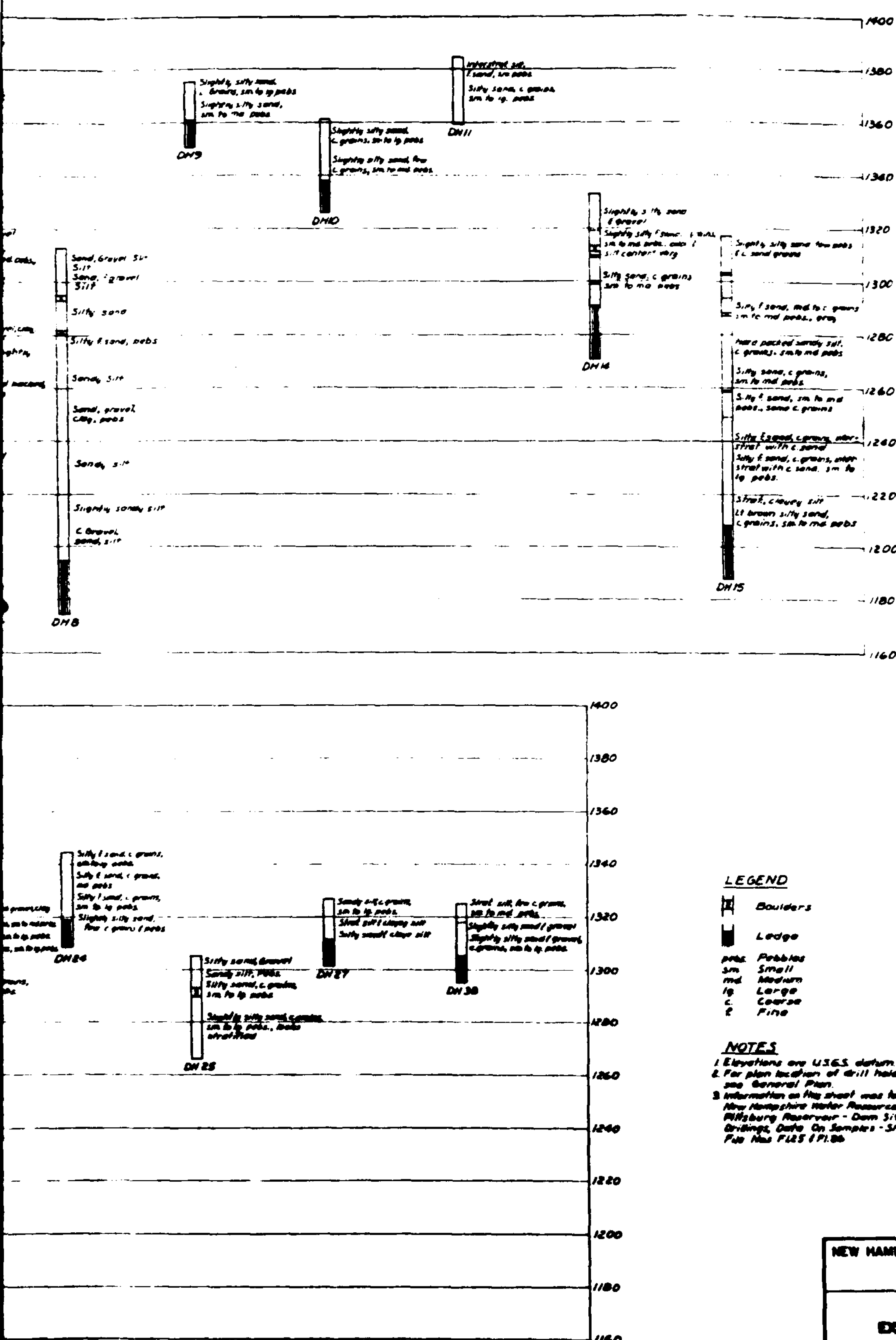
GENERAL PLAN

MAIN

CLIENT	JOB	PLATE
1318	11	I



FILE NO. 4454 01 B76



LEGEND

Boulders

Ledge

pebs. Pebbles
sm Small
md Medium
lg Large
c. Coarse
f Fine

NOTES

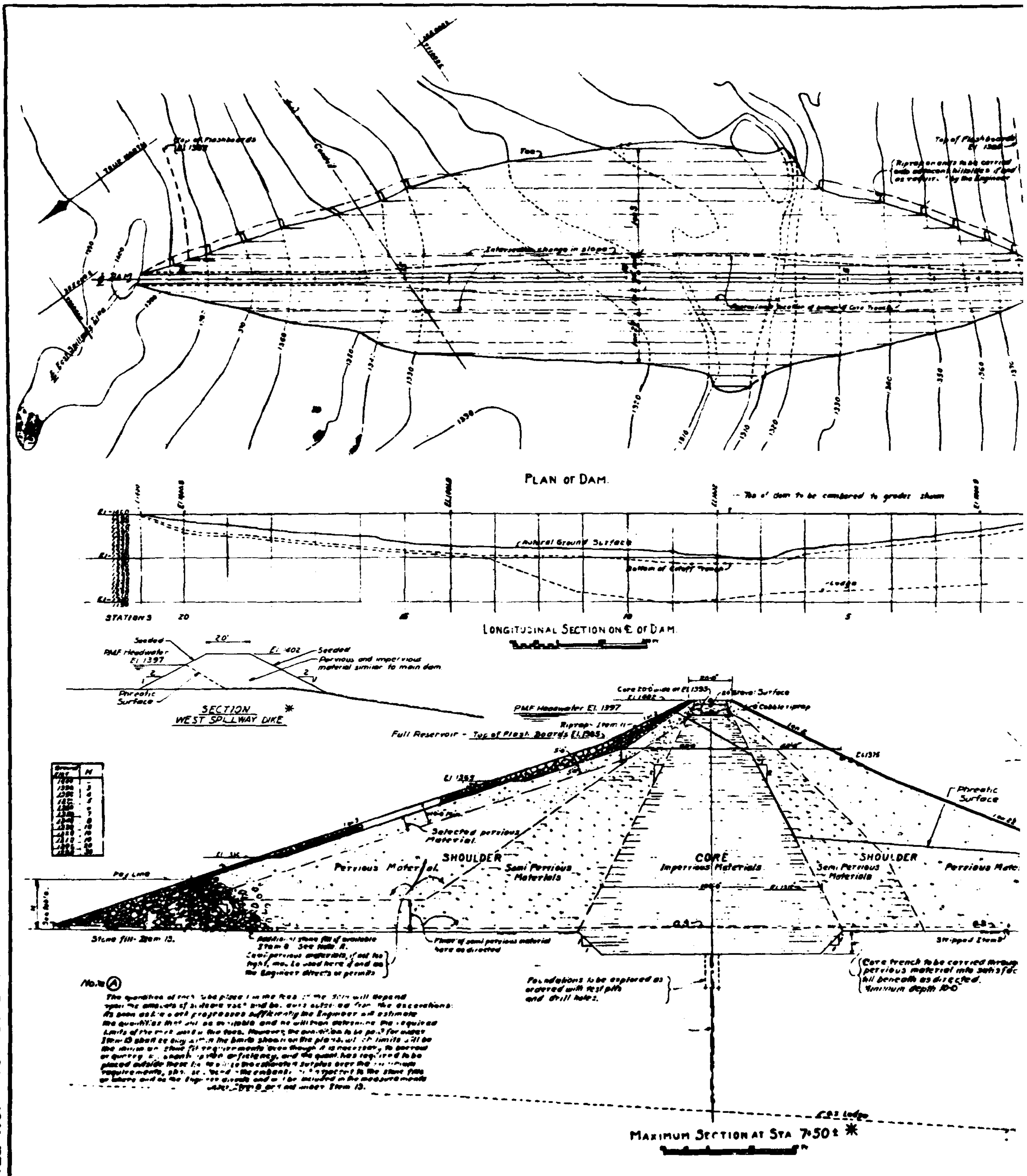
1. Elevations are USGS datum.
2. For plan location of drill holes see General Plan.
3. Information on this sheet was taken from New Hampshire Water Resources Board - Pittsburg Reservoir - Dam Site, Exploratory Drillings, Data On Samples - Sheets 1 & 2 of 2 - File Nos F125 & P1.86

NEW HAMPSHIRE WATER RESOURCES BOARD
Concord N. H.
MURPHY DAM

DAM SITE
EXPLORATORY DRILL LOGS

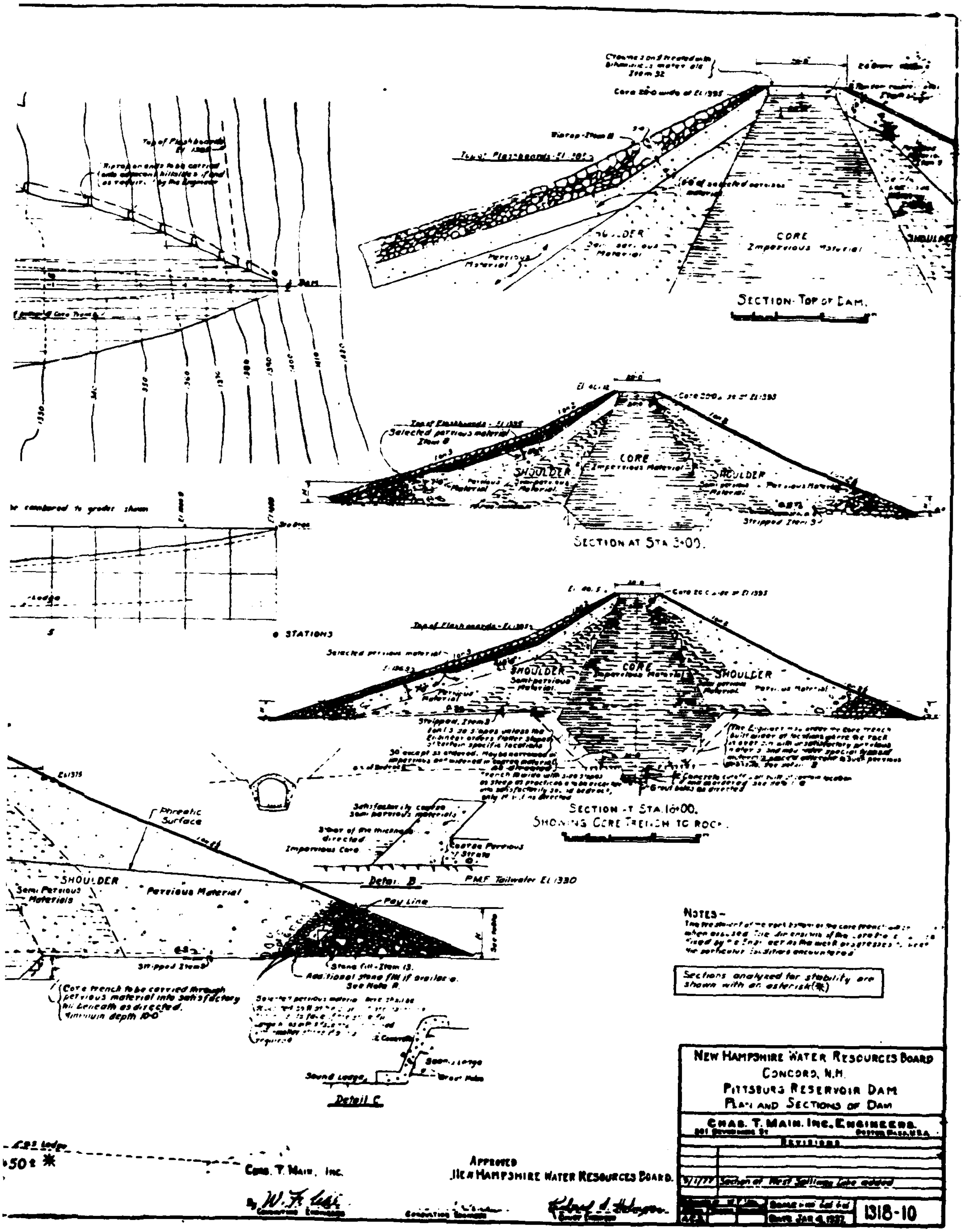
MAIN

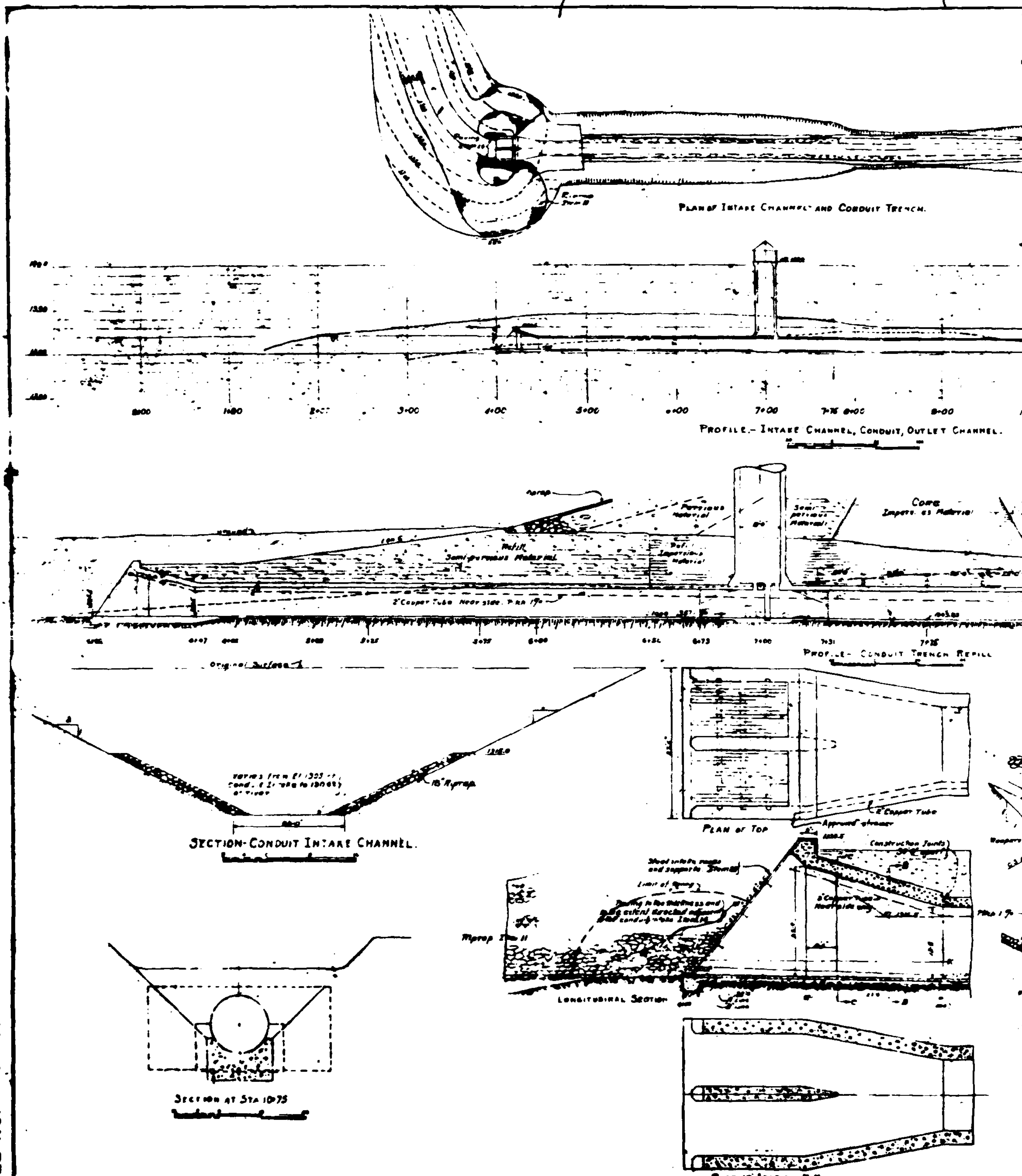
COMP	JOB	DWG
1318	11	SK-1



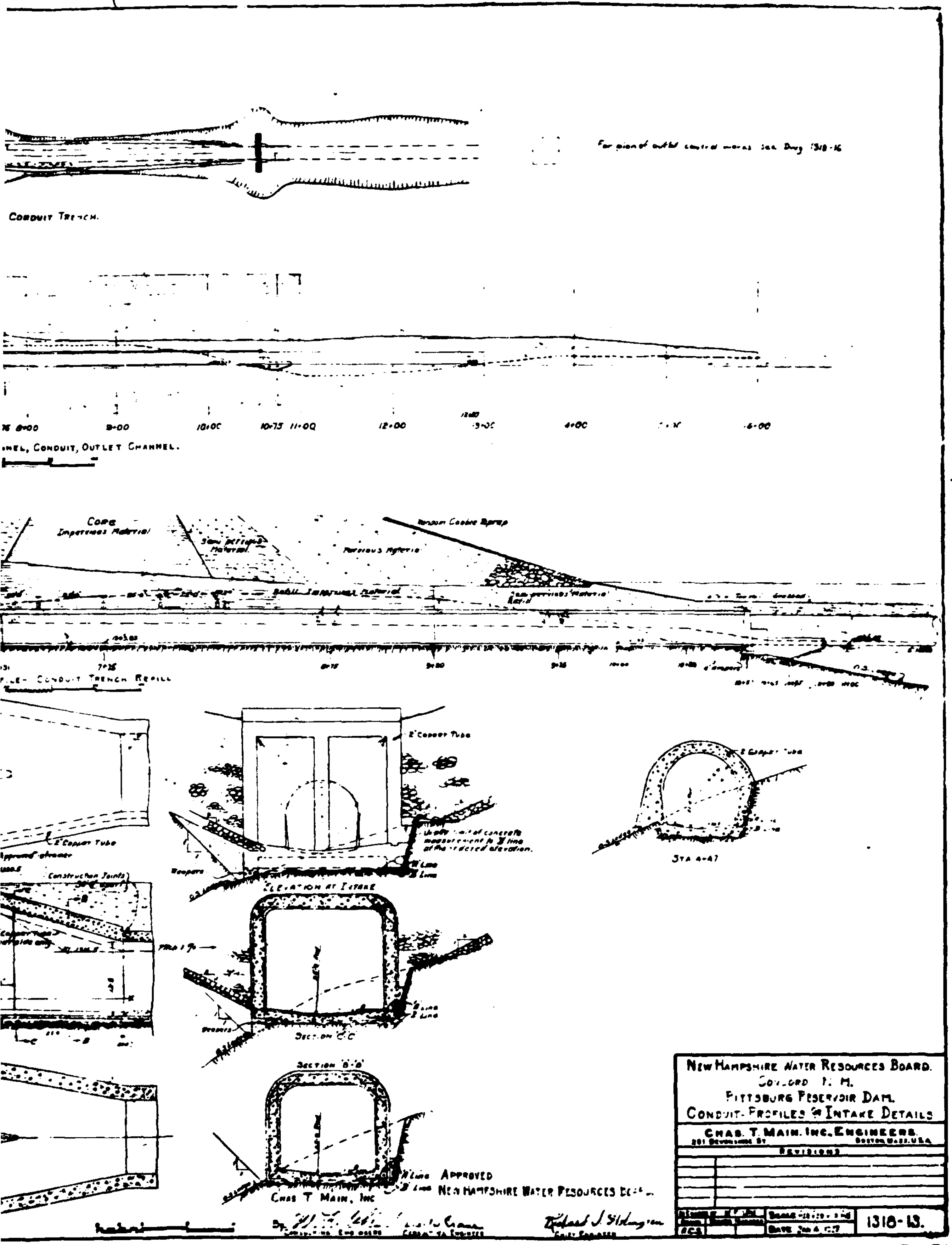
FILE NO. 4454 01 B77

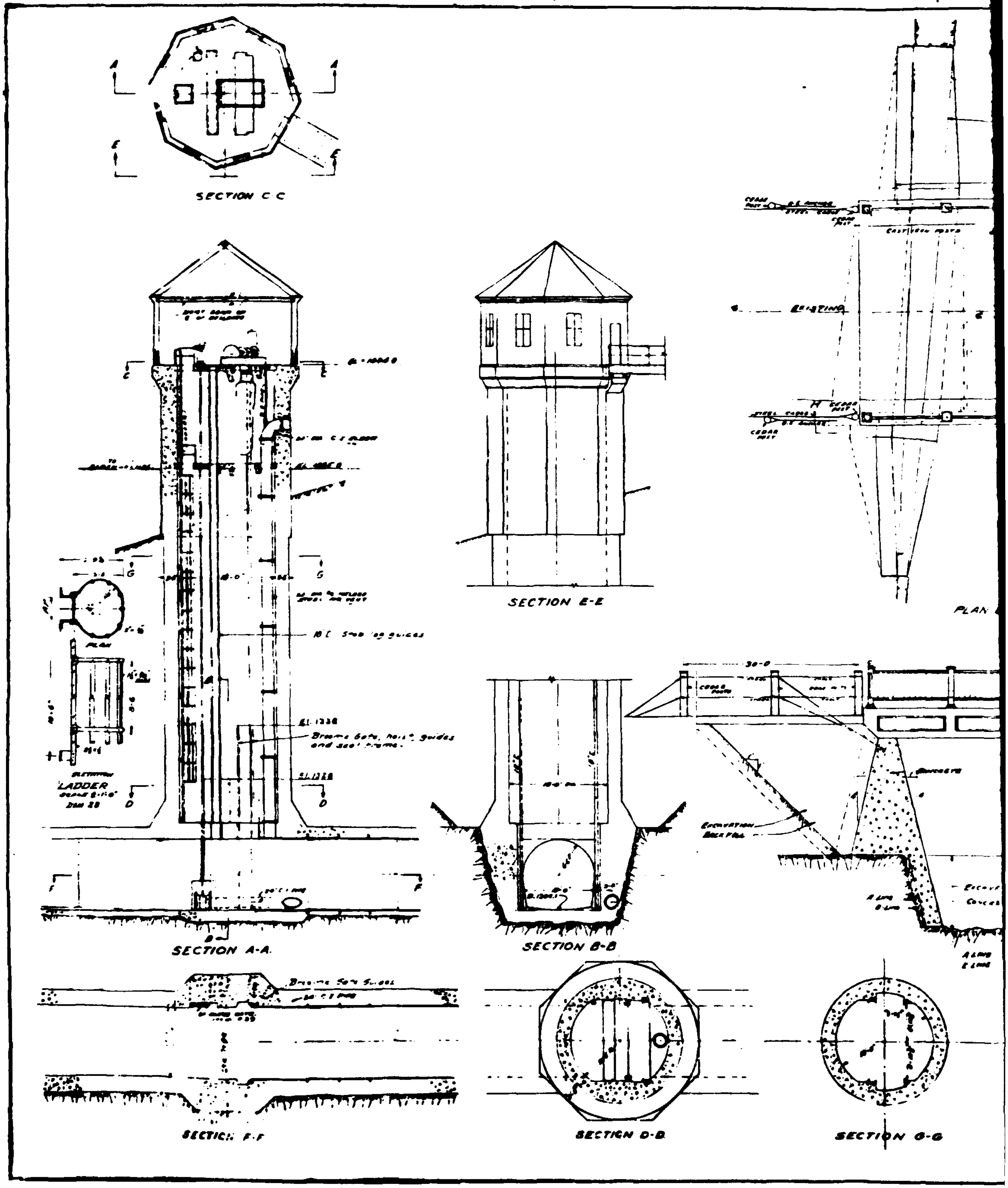
2


SECTION- TOP OF DAM.
CORE
Impervious Material
SHOULDER
Pervious Material
SECTION AT STA 3+00.
CORE
Impervious Material
SHOULDER
SECTION AT STA. 16+00.
SHOWING CORE TRENCH TO ROCK.
Phreatic Surface
SHOULDER
Semi Pervious Materials
Pervious Material
Pay Line
Stripped Item 3
Stone fill- Item 13.
Additional stone fill if available.
Core trench to be carried through pervious material into satisfactory bearing beneath as directed. Minimum depth 10-0
Detail B
PMF Tailwater El 1330
Detail C
Sound Ledge
STATIONS
NOTES -
Sections analyzed for stability are shown with an asterisk(*)
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
PLAN AND SECTIONS OF DAM
CHAS. T. MAIN, INC. ENGINEERS
REVISIONS
Section of West Spillway Lake added
1318-10
APPROVED
NEW HAMPSHIRE WATER RESOURCES BOARD.
CHAS. T. MAIN, INC.

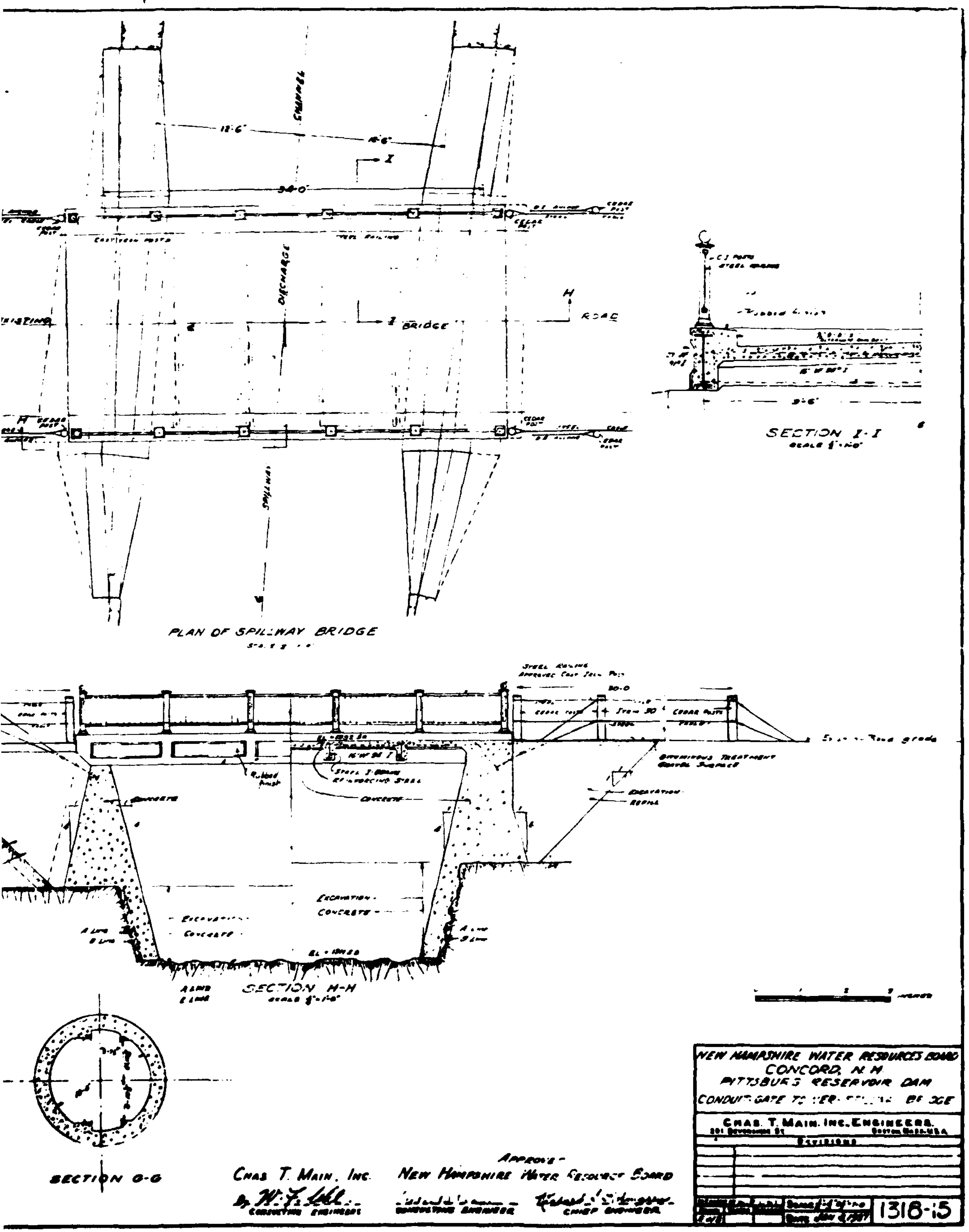


FILE NO. 4454 01 B78

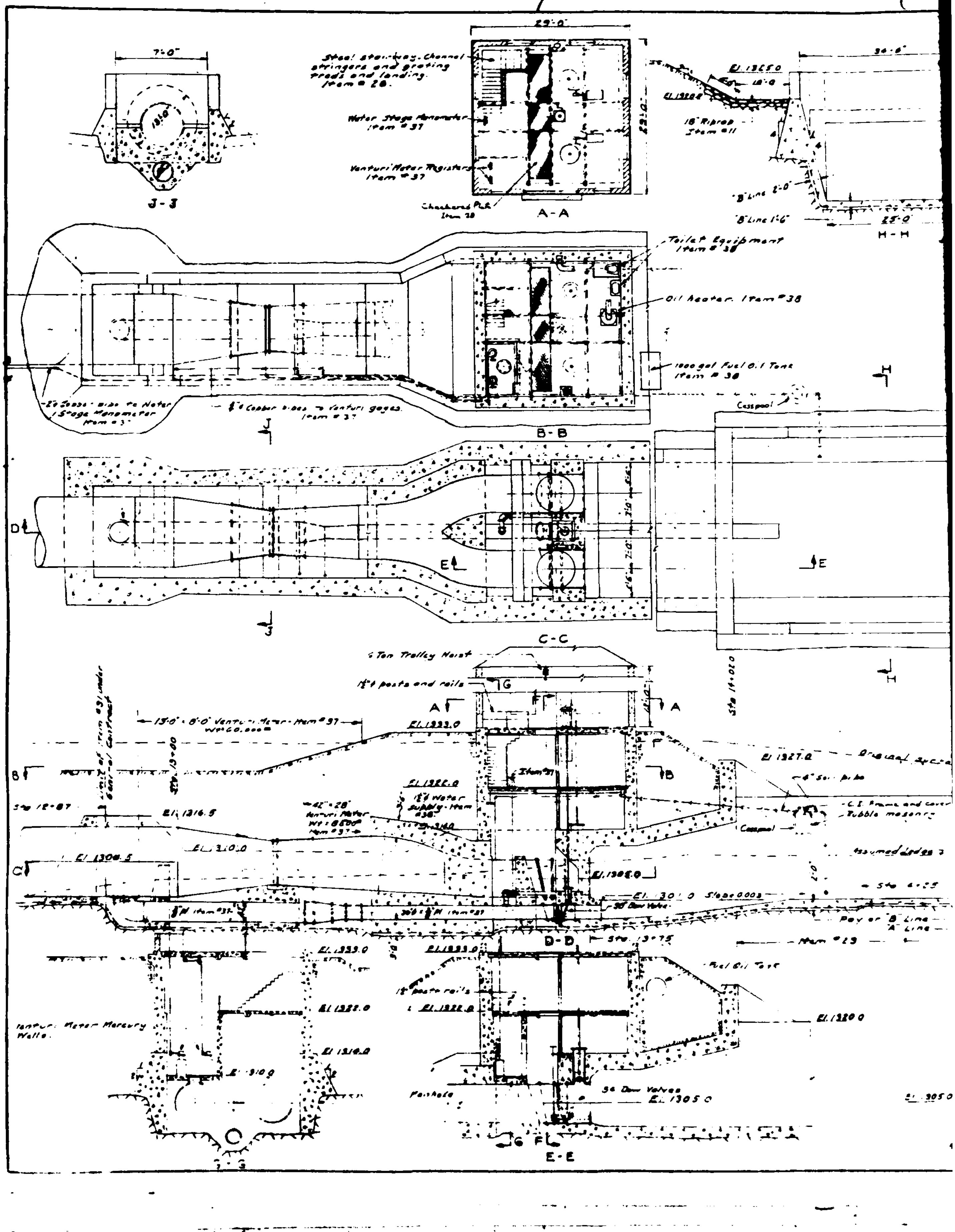

For plan of outlet control works see Dwg 1318-16
Conduit Trench.
9+00
10+00
10+75 11+00
12+00
Channel, Conduit, Outlet Channel.
Core
Impervious Material
Semi pervious Material
Pervious Material
Random Cobble Riprap
Backfill Impervious Material
Semi-pervious Material
Conduit Trench Refill
2" Copper Tube
Construction Joints
Elevation at Intake
Sta 4+47
Section C-C
Section B-B
Approved
New Hampshire Water Resources Board
Chas T Main, Inc
Chief Engineer
New Hampshire Water Resources Board.
Concord N. H.
Pittsburg Reservoir Dam.
Conduit-Profiles & Intake Details
Chas. T. Main, Inc. Engineers.
201 Devonshire St Boston Mass. U.S.A.
Revisions
1318-13.



FILE NO. 4454 01 B79

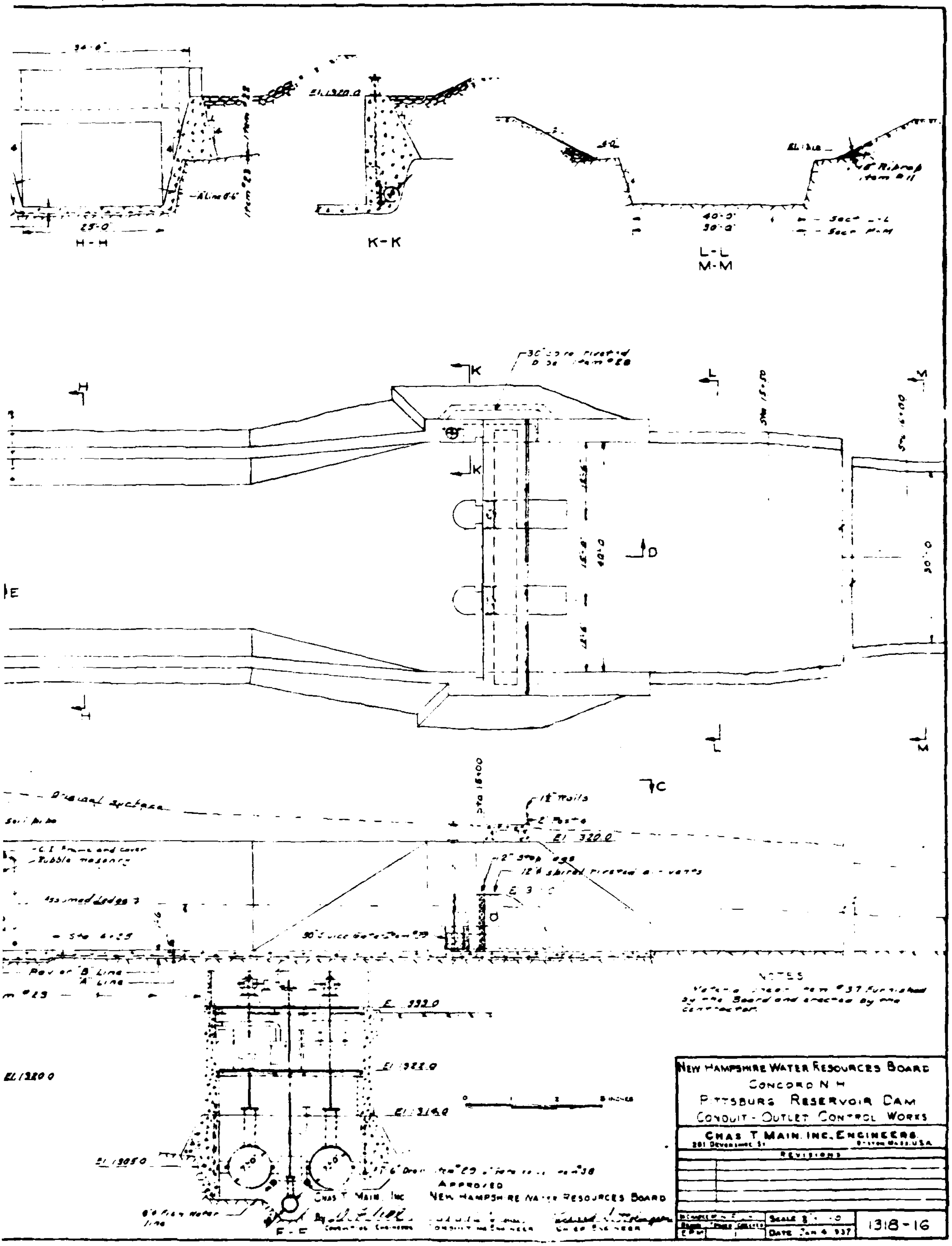

CHANNEL
12'-6"
16'-6"
34'-0"
DISCHARGE
BRIDGE
ROAD
SPILLWAY
PLAN OF SPILLWAY BRIDGE
SECTION I-I
STEEL RAILING
RUBBED FINISH
STEEL I-BEAMS
REINFORCING STEEL
CONCRETE
EXCAVATION
BITUMINOUS TREATMENT
GRAVEL SURFACE
EXCAVATION
REFILL
ROAD GRADE
CEDAR POSTS
SECTION H-H
SECTION G-G
CHAS T. MAIN, INC.
CONSULTING ENGINEERS
APPROVED -
NEW HAMPSHIRE WATER RESOURCES BOARD
CONSULTING ENGINEER
CHIEF ENGINEER
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
CONDUIT GATE
CHAS. T. MAIN, INC. ENGINEERS
REVISIONS
1318-15

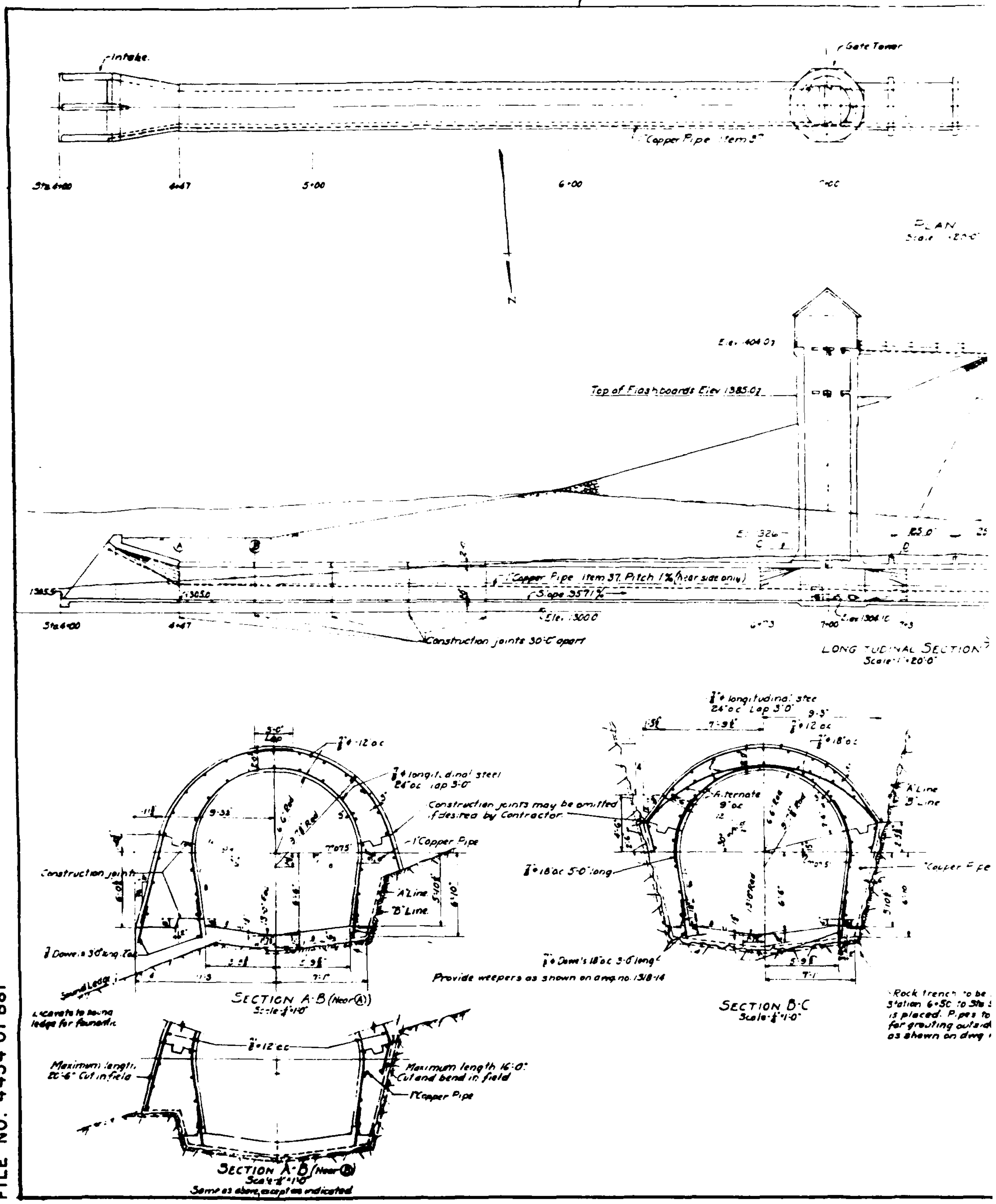
B-52



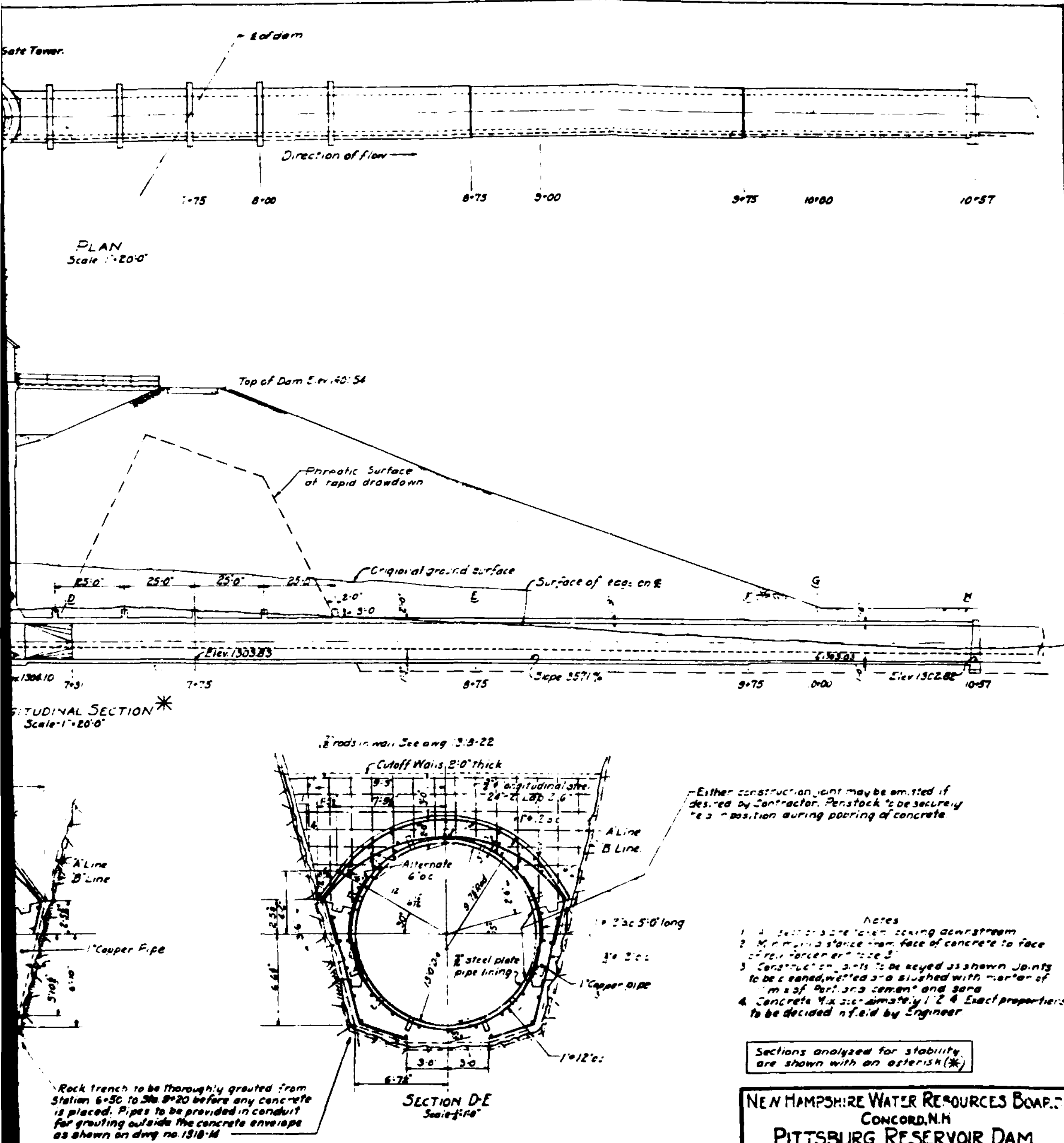
FILE NO. 4454 01 B80

2


H-H
K-K
L-L
M-M
El. 1320.0
Sta. 18+00
El. 320.0
12" Rails
2" Posts
Original surface
Assumed ledge
30" Sluice Gate
E-E
NOTES
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD N. H.
PITTSBURG RESERVOIR DAM
CONDUIT - OUTLET CONTROL WORKS
CHAS. T. MAIN, INC. ENGINEERS
REVISIONS
APPROVED
CHAS. T. MAIN, INC.
NEW HAMPSHIRE WATER RESOURCES BOARD
1318-16



FILE NO. 4454 01 B81



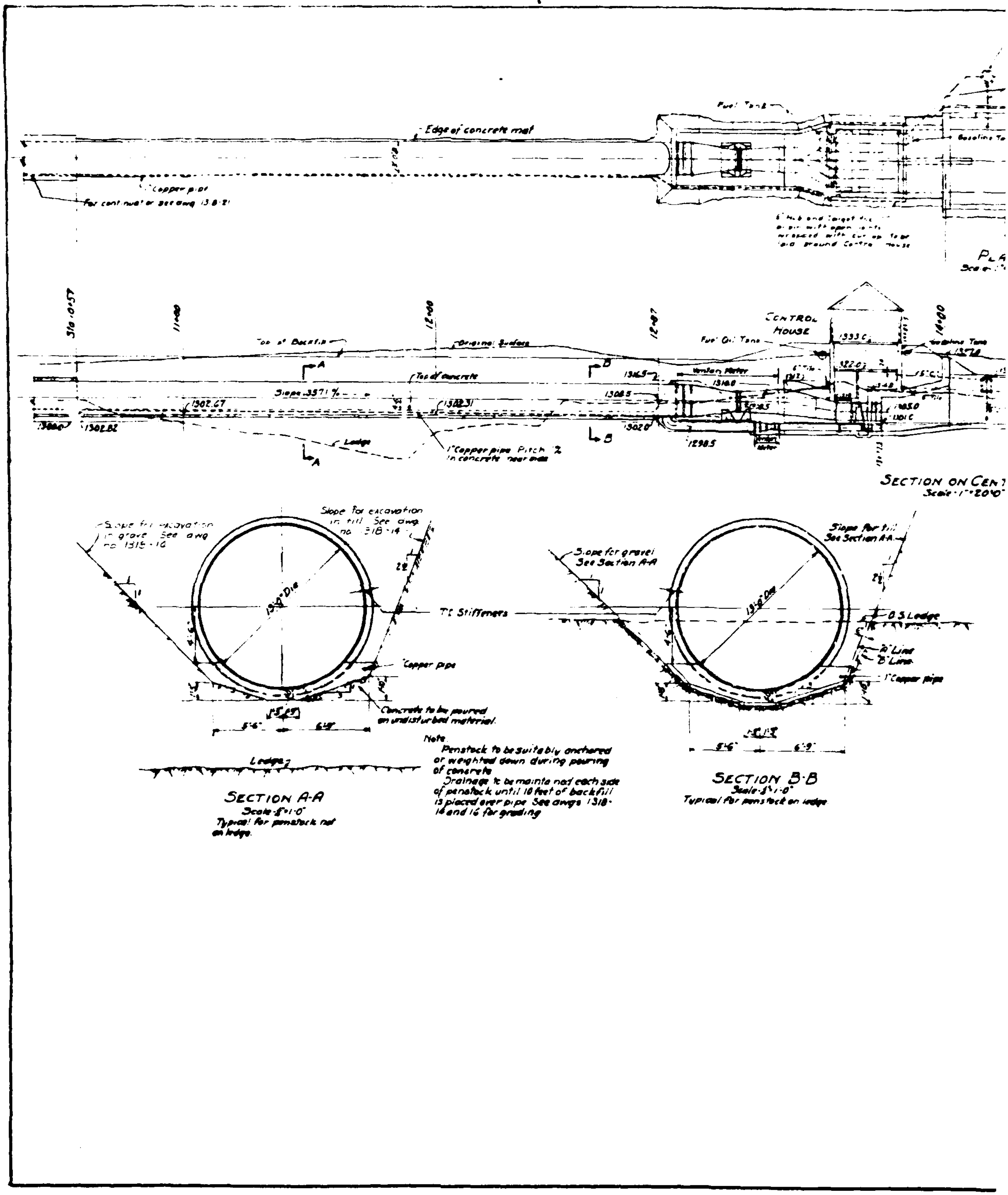
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
CONDUIT-CONCRETE DETAILS-SHEET I

CHAS. T. MAIN, INC., ENGINEERS.
201 Devonshire St · Boston, Mass. U.S.A.

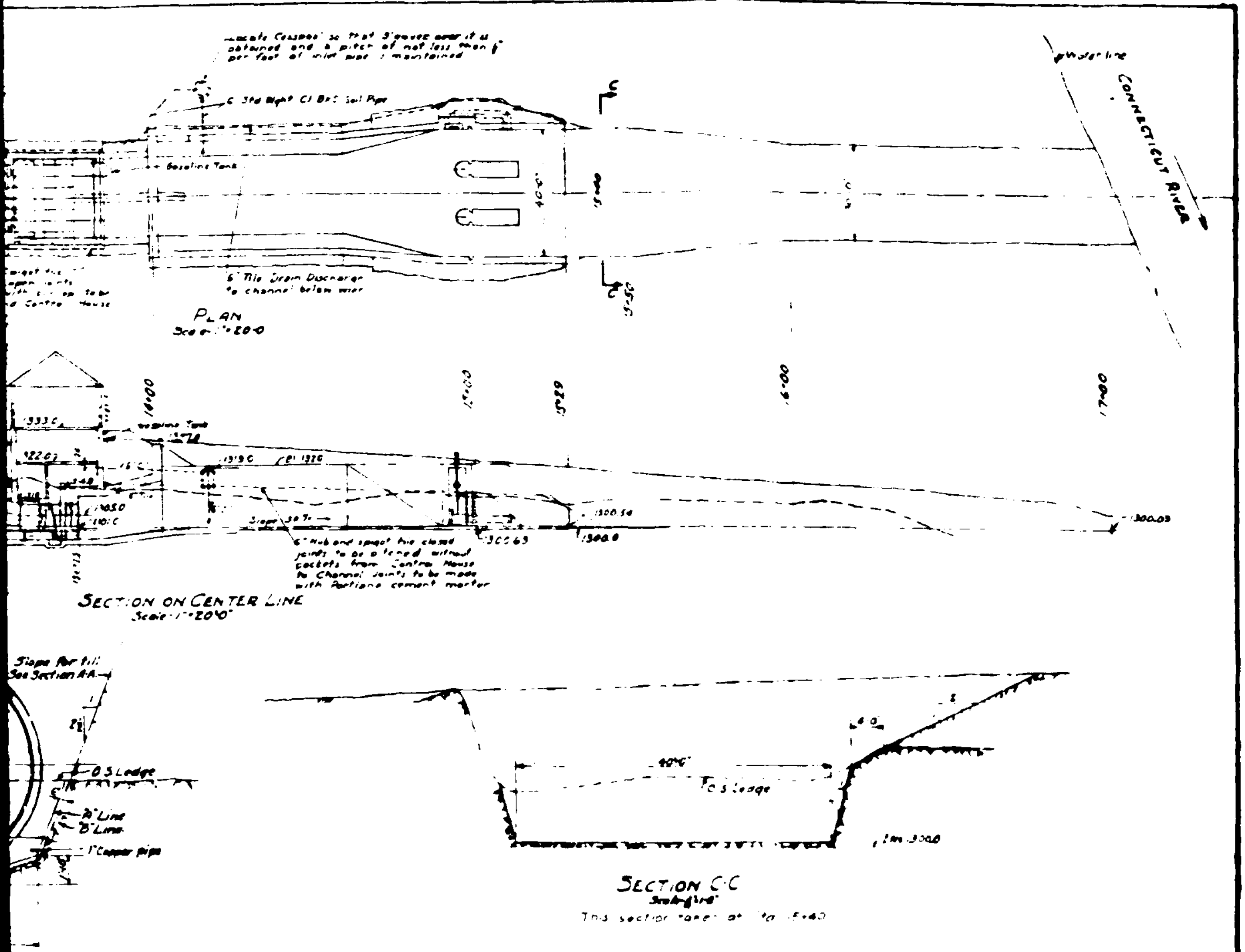
REVISIONS	
6-30-38	General Revision
9-2-38	Minor Revision
1-30-39	Copper tube changed to 1" copper pipe

Scale: as noted · Date: Aug 11, 1938

1318-21



FILE NO. 4454 01 882



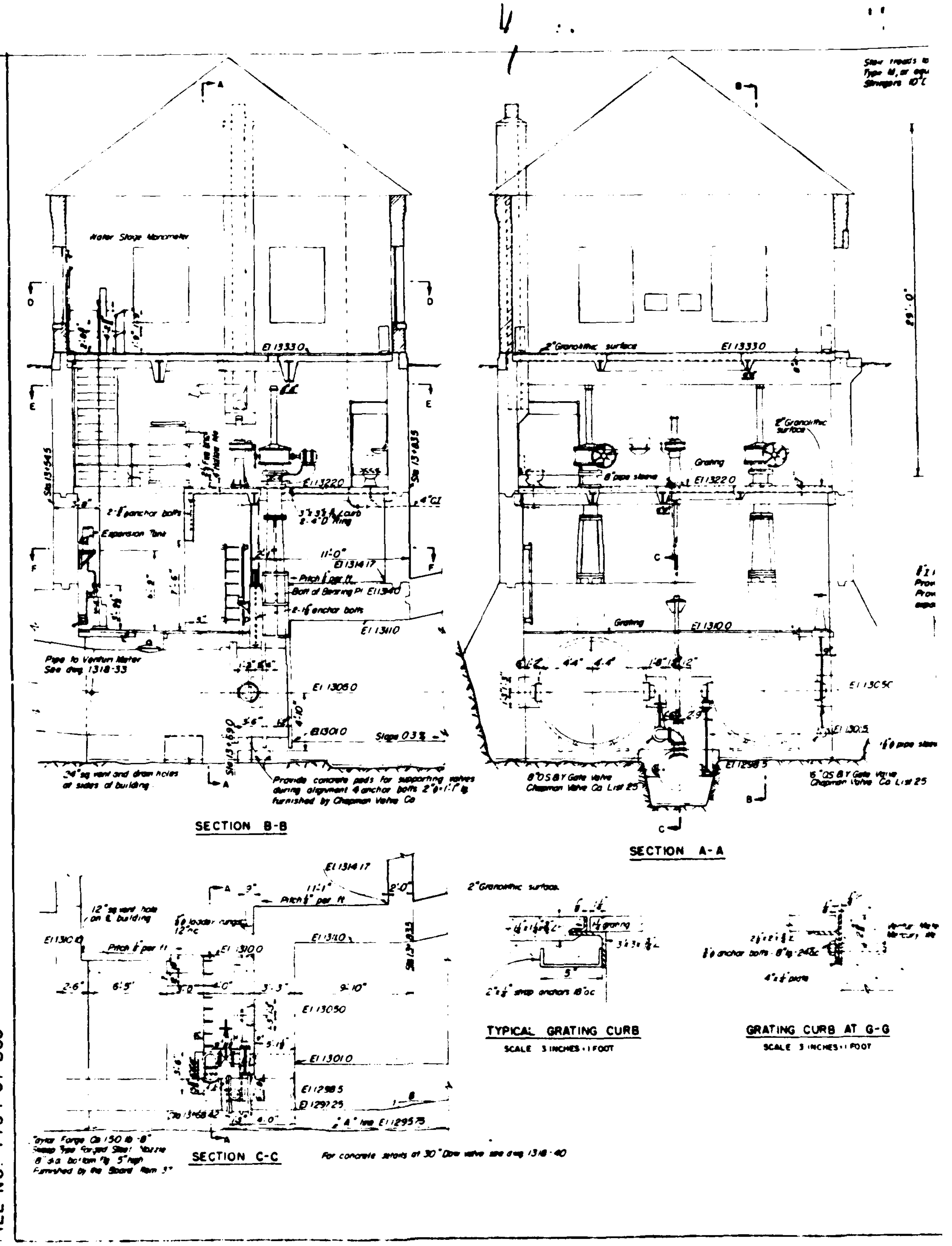
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
OUTLET CONTROL WORKS-GENERAL PLAN & SECTIONS

CHAS. T. MAIN, INC., ENGINEERS
201 DEVONSHIRE ST. BOSTON, MASS. U.S.A.

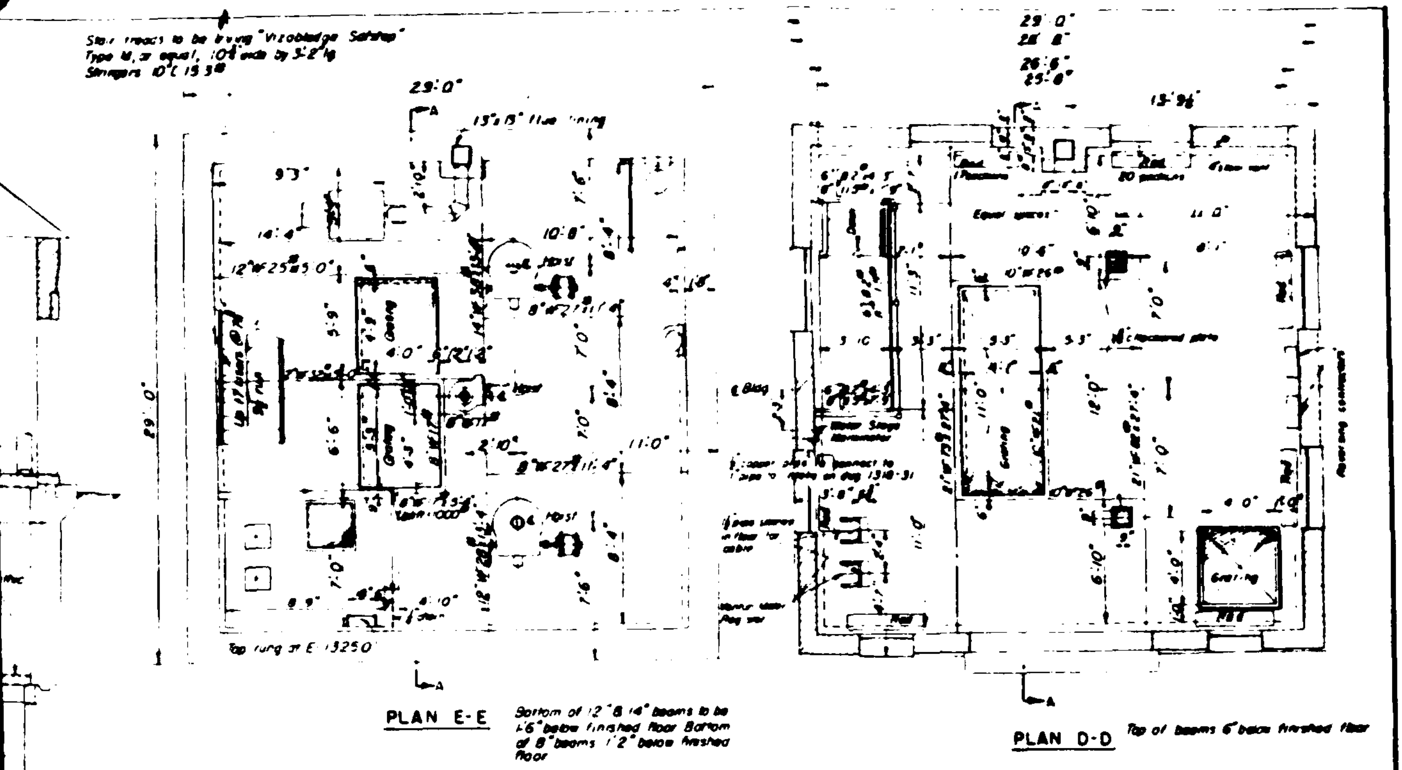
REVISIONS

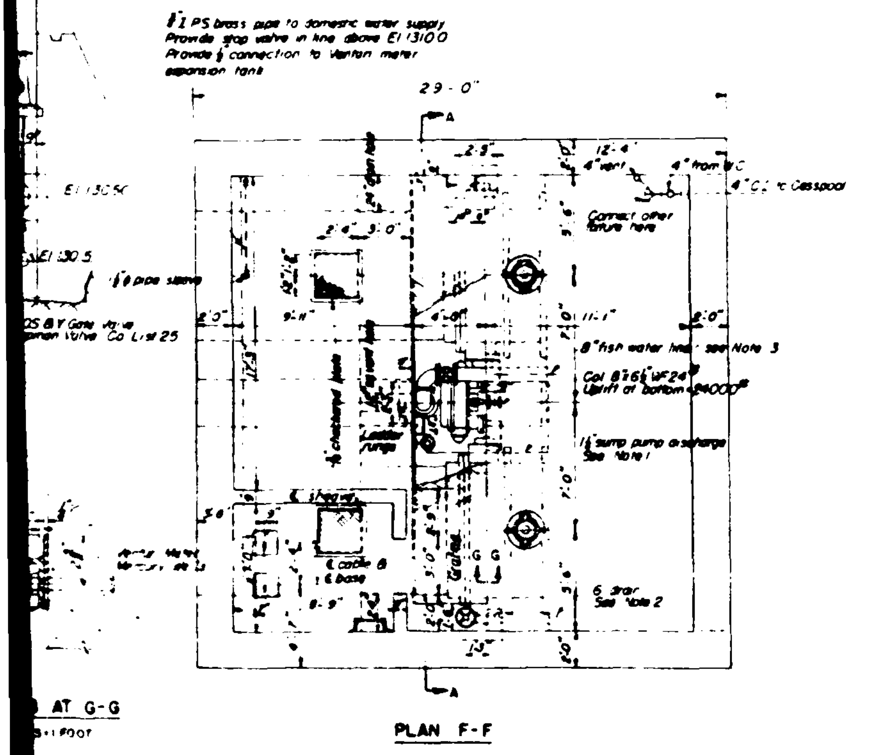
SCALE-AS NOTED
DATE-OCT 25,1938

1318-31



SECTION B-B
SECTION A-A
SECTION C-C
TYPICAL GRATING CURB
SCALE 3 INCHES = 1 FOOT
GRATING CURB AT G-G
SCALE 3 INCHES = 1 FOOT
Water Stage Manometer
El 1333.0
El 1322.0
El 1314.17
El 1310.0
El 1306.0
El 1301.0
2" Granolithic surface
2-1 1/2" anchor bolts
Expansion Tank
Pipe to Venturi Meter See dwg 1318-33
24" sq vent and drain holes at sides of building
Provide concrete pads for supporting valves during alignment 4 anchor bolts 2"⌀ x 1'-1" lg furnished by Chapman Valve Co
8" OS & Y Gate Valve Chapman Valve Co List 25
16" OS & Y Gate Valve Chapman Valve Co List 25
Slope 0.3%
Grating
For concrete details at 30" Dow valve see dwg 1318-40
2" Granolithic surface
2"x 1/4" strap anchors 18" oc
FILE NO. 4454 01 883





NOTES

1. Install a gate valve and a check valve in the 1½" sump pump discharge line. Bracket pump shaft securely to wall.
2. 6" drain to be steel pipe. Valve to be OS & Y iron body, wedge gate, bronze mounted, std wght, with extension stem and floor stand at El 1300.0
3. Fish water line similar to above except 8" dia. Elbows to be std wght C.I. ftgs furnished by the Board. Item No 5
4. Sump pump to be Penberthy Injector Co. Model 3? Furnished by the Board
5. All gratings to be ¾" Irving Type "W" No. 5 or equal
6. All structural steel connections to be riveted

For concrete and reinforcing details see dwgs 1318-34 and 1318-36

NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.

PITTSBURG RESERVOIR DAM

OUTLET CONTROL HOUSE - PLANS & SECTIONS

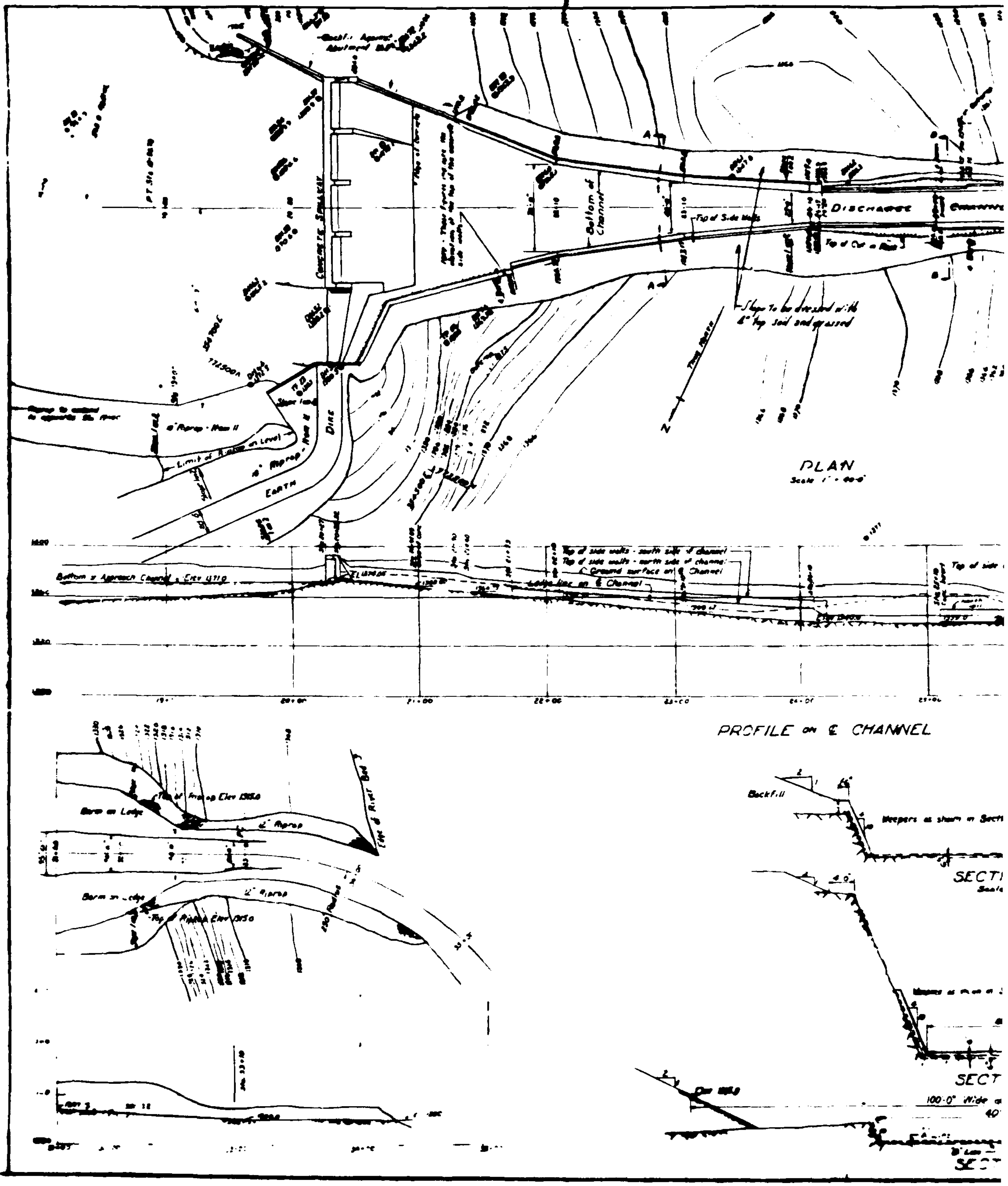
CHAS. T. MAIN, INC., ENGINEERS
201 Devonshire St. Boston Mass. U.S.A.

REVISIONS

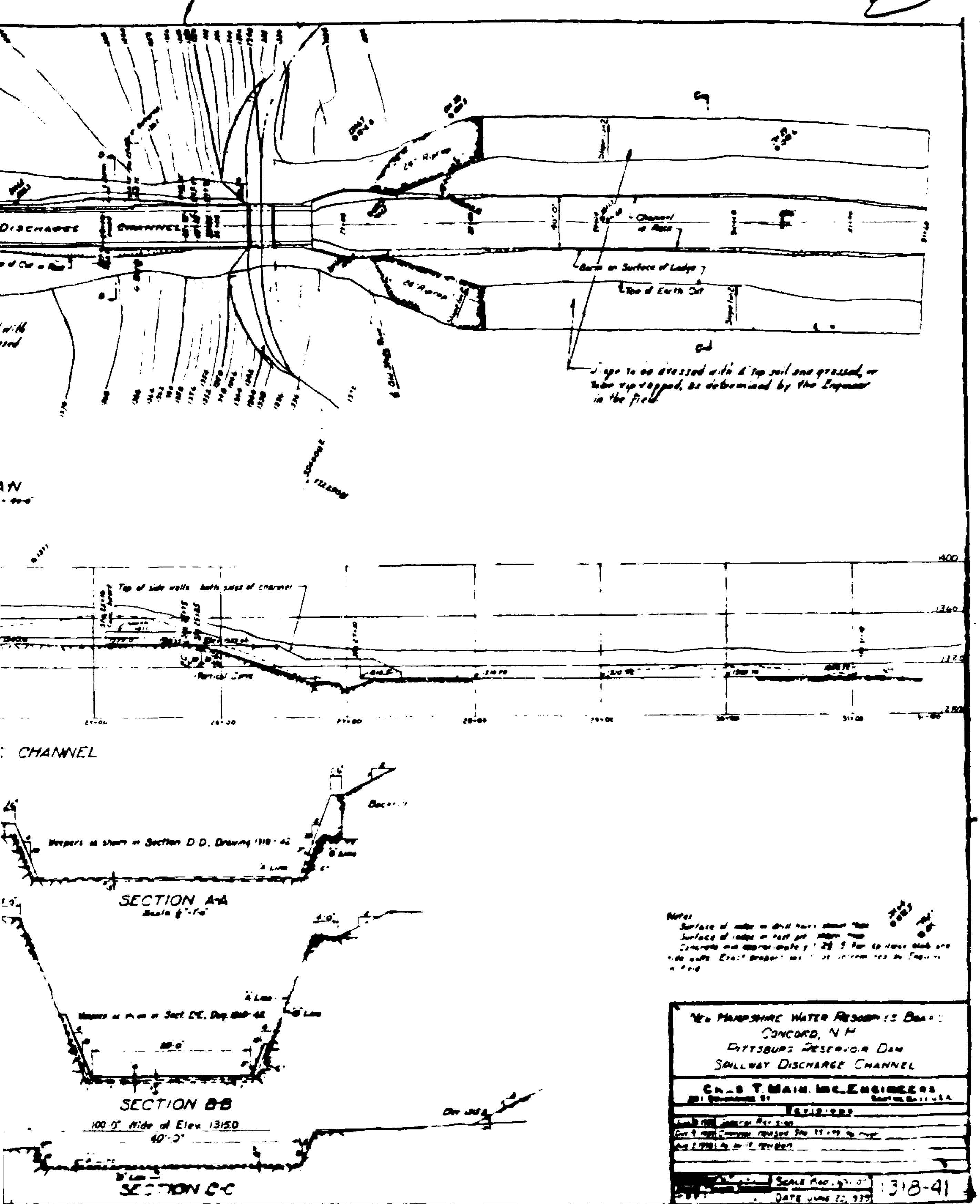
Aug 7, 1939 GENERAL REVISION
Oct 1939 RADIATORS ADDED - PLAN D-D

Scale ¼" = 1'-0"
Date July 10, 1939

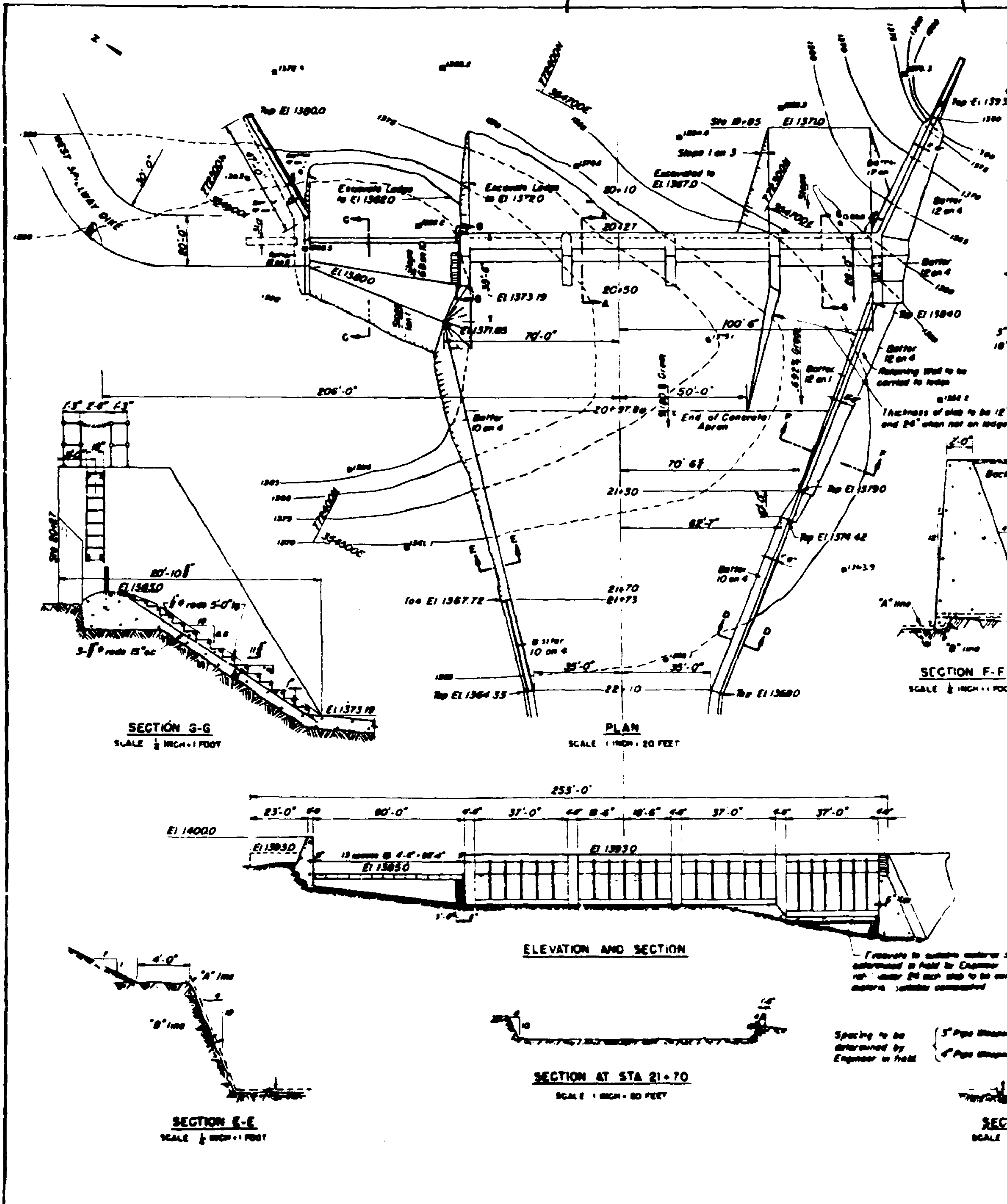
1318 - 35



FILE NO. 4454 01 884

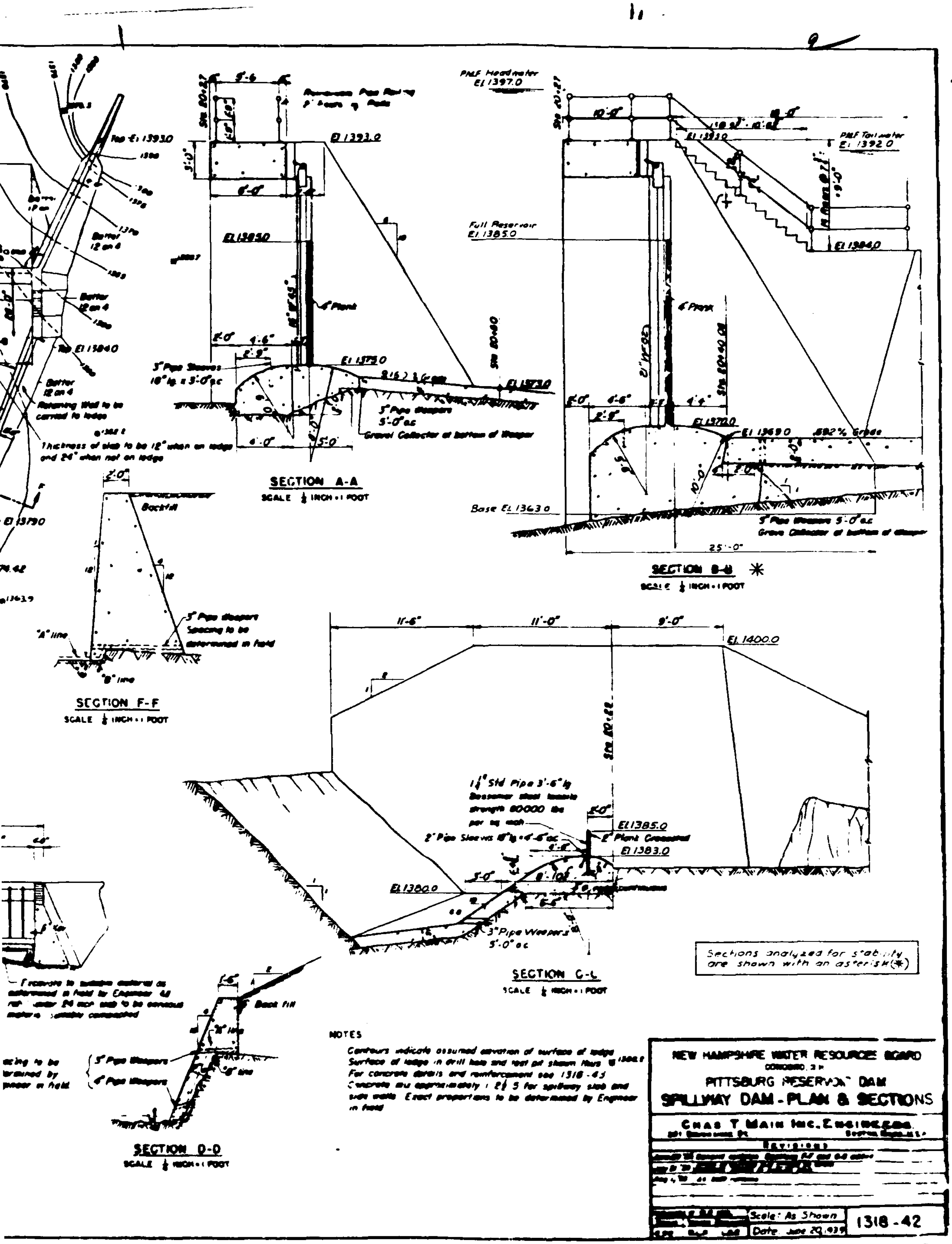


DISCHARGE CHANNEL
Berm on Surface of Ledge
Toe of Earth Cut
Slope to be dressed with 4" top soil and grassed, or hand rip rapped, as determined by the Engineer in the field
Top of side walls both sides of channel
Vertical Curve
CHANNEL
Weepers as shown in Section D D, Drawing 1318-42
SECTION A-A
SECTION B-B
SECTION C-C
100'-0" Wide at Elev. 1315.0
40'-0"
Notes
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
SPILLWAY DISCHARGE CHANNEL
CHAS T. MAIN, INC. ENGINEERS
1318-41



FILE NO. 4454 01 B85

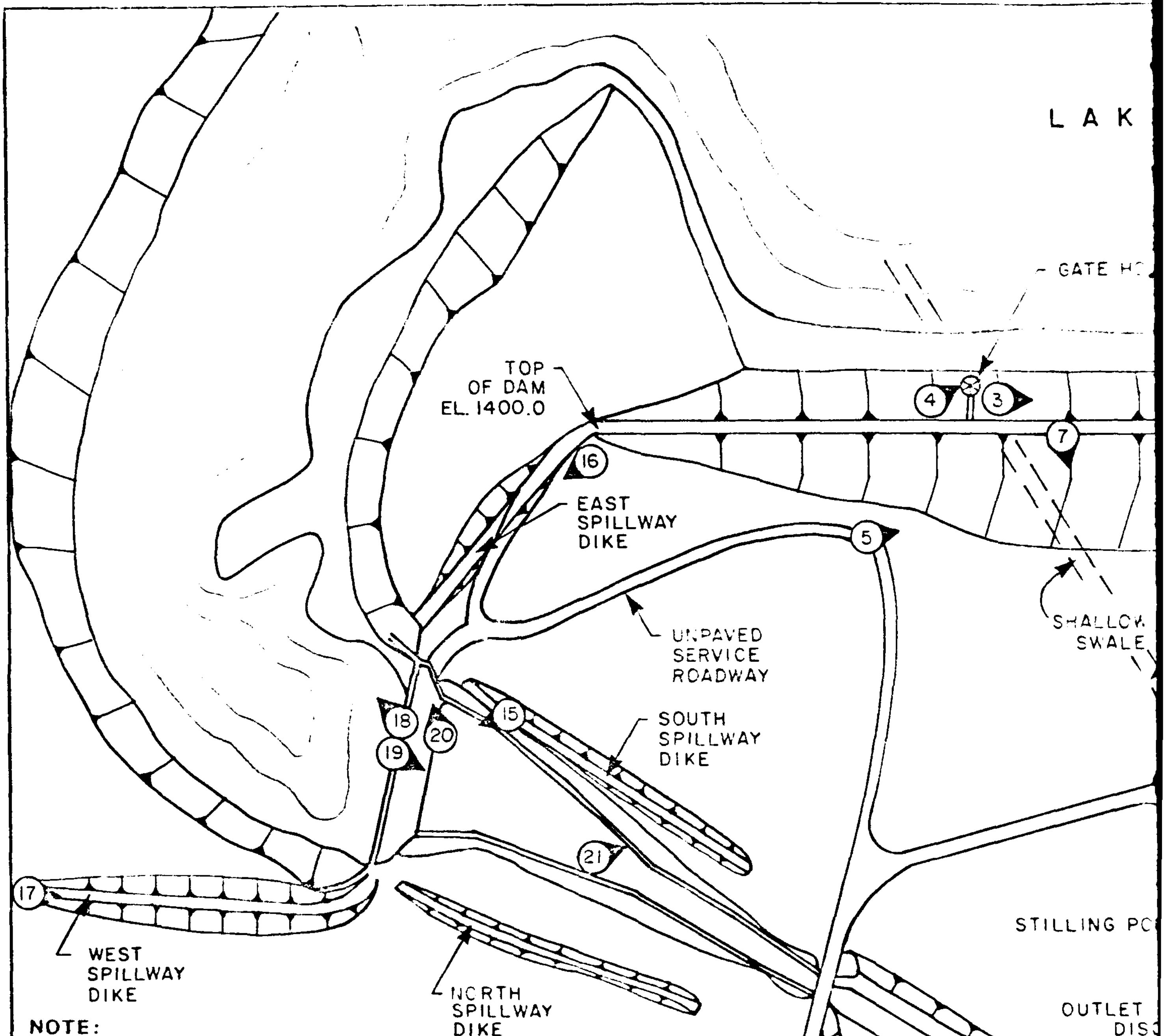
2



SECTION A-A
SCALE ½ INCH = 1 FOOT
SECTION B-B ✱
SCALE ½ INCH = 1 FOOT
SECTION C-C
SCALE ½ INCH = 1 FOOT
SECTION D-D
SCALE ½ INCH = 1 FOOT
SECTION F-F
SCALE ½ INCH = 1 FOOT
PMF Headwater El 1397.0
PMF Tailwater El 1392.0
Full Reservoir El 1385.0
El 1393.0
El 1385.0
El 1375.0
El 1373.0
El 1370.0
El 1369.0
El 1364.0
El 1384.0
Base El 1363.0
El 1400.0
El 1383.0
El 1380.0
4" Plank
3" Pipe Sleeves 18" lg × 3'-0" oc
3" Pipe Weepers 5'-0" oc
Gravel Collector at bottom of Weeper
.892% Grade
25'-0"
11'-6"
11'-0"
9'-0"
1¼" Std Pipe 3'-6" lg
2" Pipe Sleeves 18" lg × 4'-6" oc
2" Plank Creosoted
3" Pipe Weepers 5'-0" oc
3" Pipe Weepers Spacing to be determined in field
Backfill
"A" line
"B" line
Thickness of slab to be 12" when on ledge and 24" when not on ledge
Retaining Wall to be carried to ledge
Batter 12 on 4
Top El 1393.0
Top El 1384.0
El 1379.0
Back fill
5" Pipe Weepers
4" Pipe Weepers
Sections analyzed for stability are shown with an asterisk (✱)
NOTES
Contours indicate assumed elevation of surface of ledge
Surface of ledge in drill hole and test pit shown thus
For concrete details and reinforcement see 1318-43
Concrete mix approximately 1: 2½: 5 for spillway slab and side walls. Exact proportions to be determined by Engineer in field
NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N.H.
PITTSBURG RESERVOIR DAM
SPILLWAY DAM - PLAN & SECTIONS
CHAS T MAIN INC. ENGINEERS
Revisions
Scale: As Shown
Date June 20, 1939
1318-42

APPENDIX C - [illegible]

PHOTOGRAPHS



NOTE:

PLAN DEVELOPED FROM "GENERAL PLAN", BY CHAS. T. MAIN, INC., UNDATED (SEE APPENDIX PAGE B-48) AND FIELD OBSERVATIONS MADE ON 22 APRIL 1981.

PHOTO NO. 1 WAS TAKEN FROM A LOCATION OUTSIDE THE LIMITS OF PLAN.

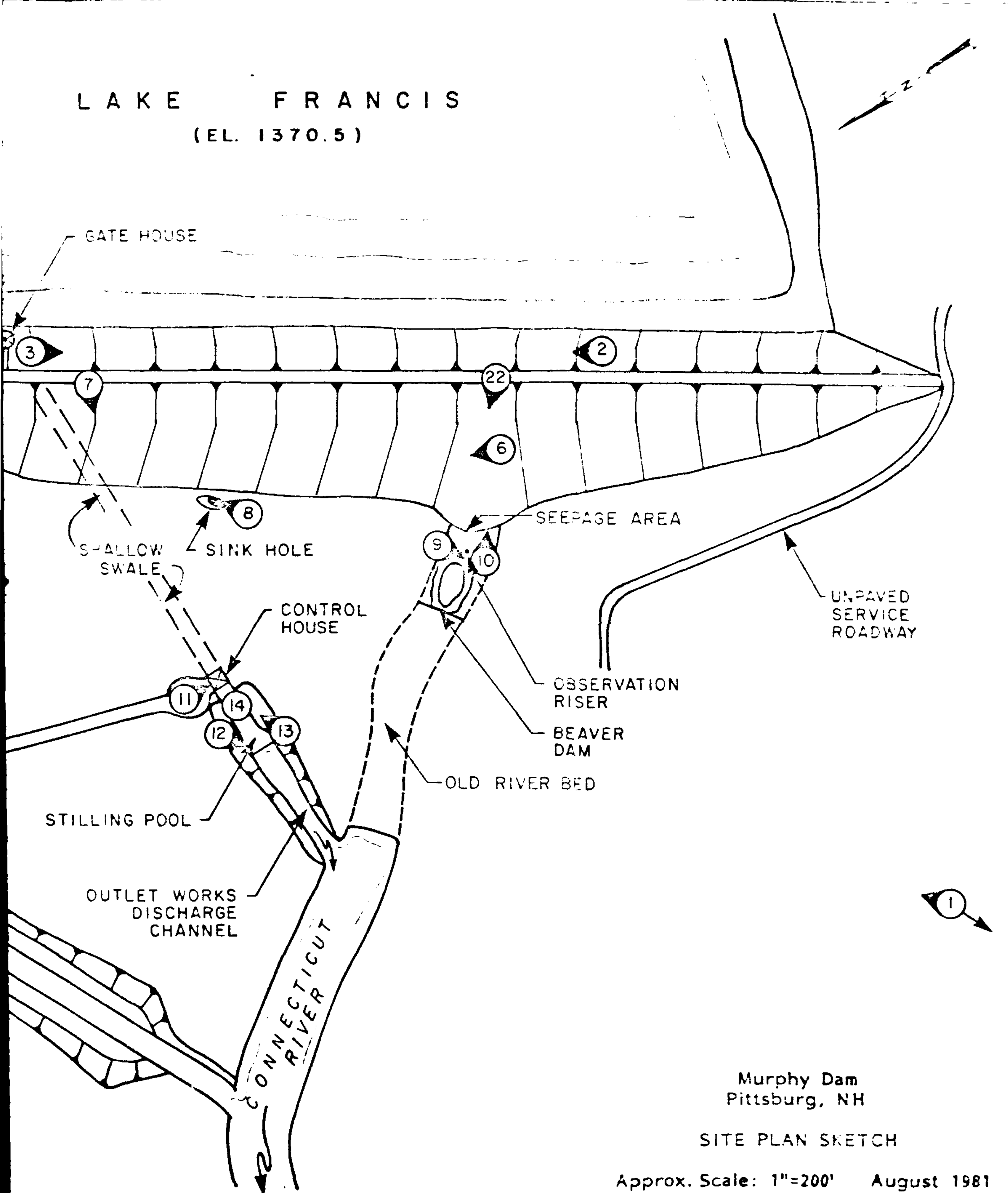
LEGEND:

2 PHOTO NUMBER AND DIRECTION OF VIEW

HALEY & ALDRICH INC
CAMBRIDGE MASSACHUSETTS

FILE NO 4454 B86

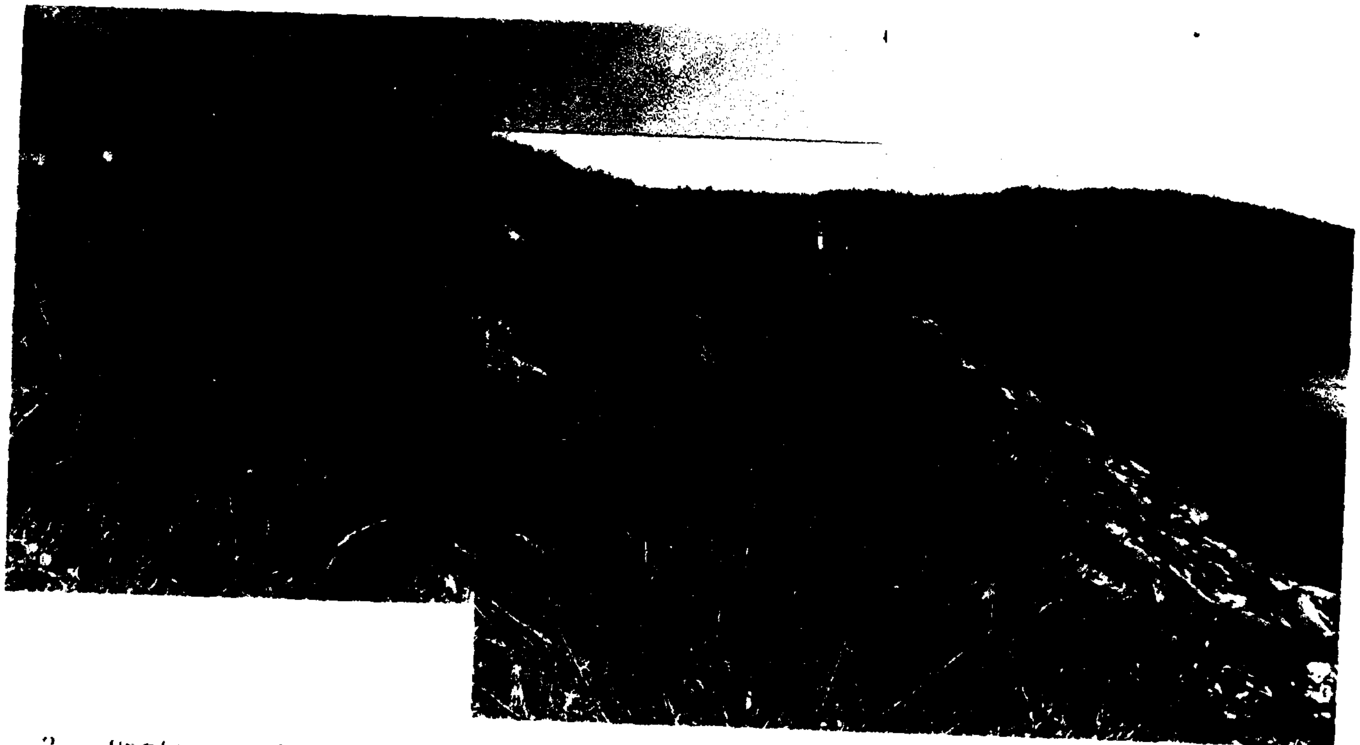
BRUNING 44-141 35356



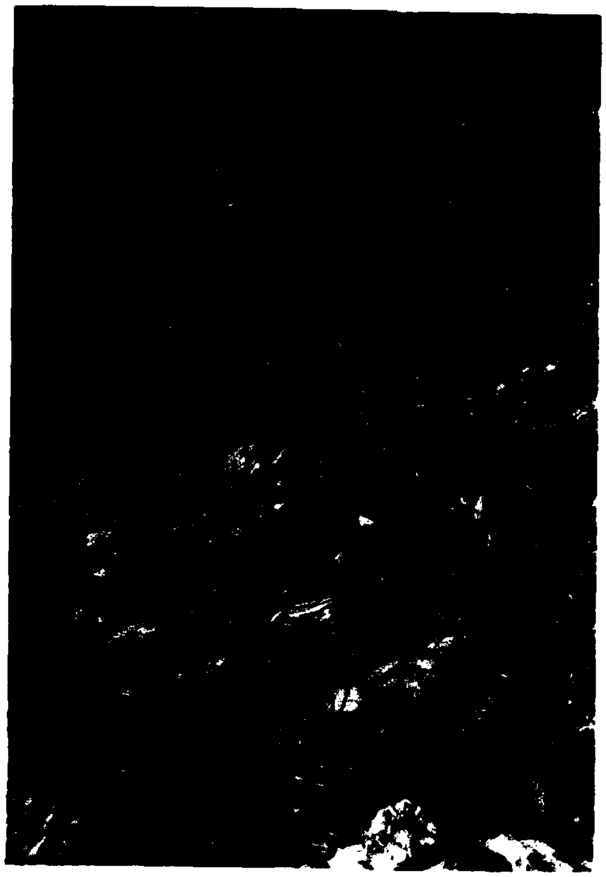
Murphy Dam
Pittsburg, NH

SITE PLAN SKETCH

Approx. Scale: 1"=200' August 1981

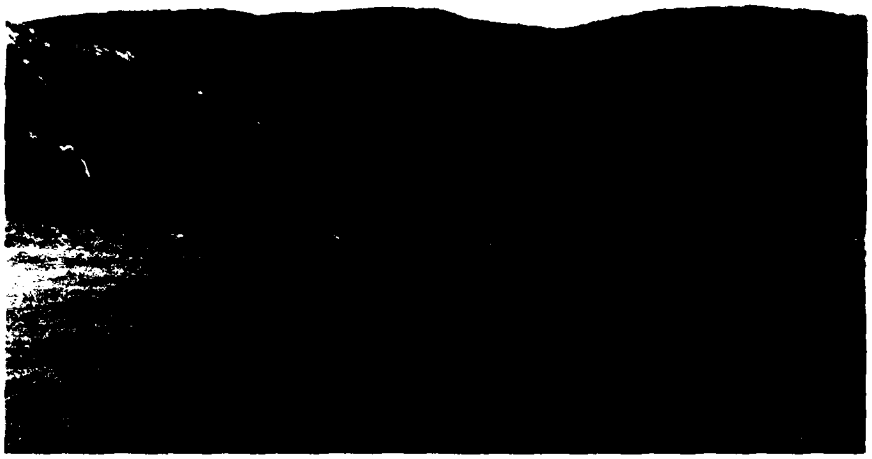


2. Upstream slope of dam embankment and gate house from left side



3. Upstream slope of dam embankment and left dam abutment from gate house

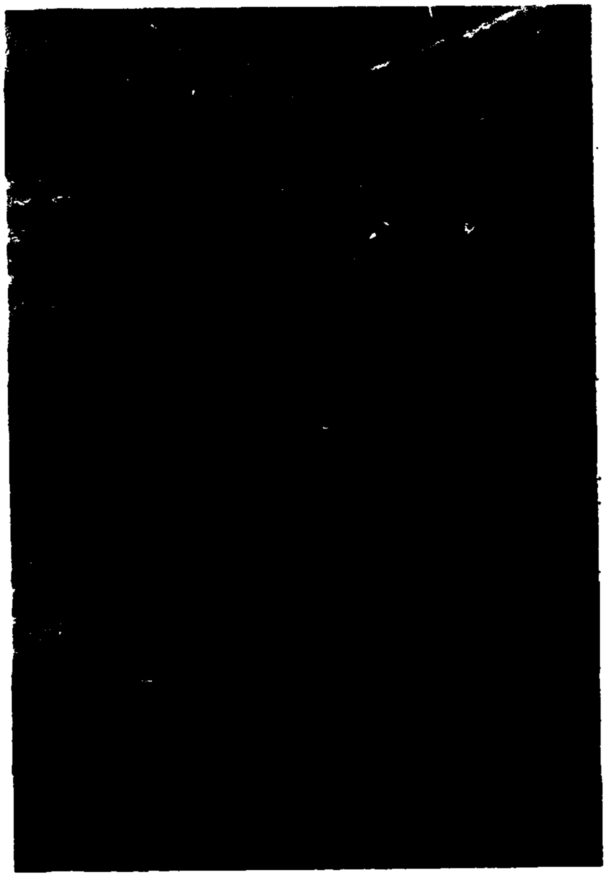
4. Upstream slope at location of gate house



5. Overview of dam embankment showing downstream side

6. Heavy derrick stone on downstream slope

7. Control house and soft wet swale downstream of dam

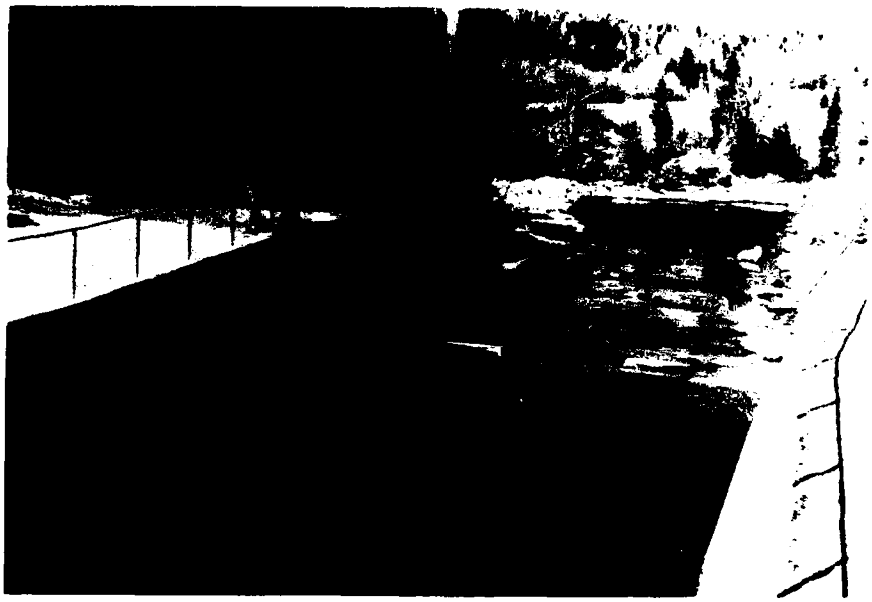


8. Sink hole at downstream toe

9. Observation riser located within river bed immediately downstream of dam embankment

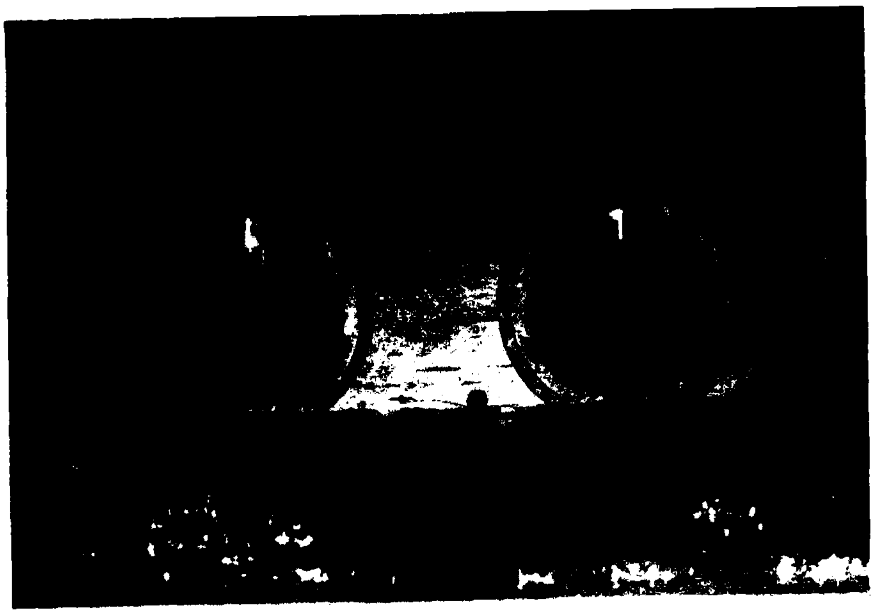
10. Area of accumulated silt and sand, downstream of toe of dam, at river bed

11. Control house

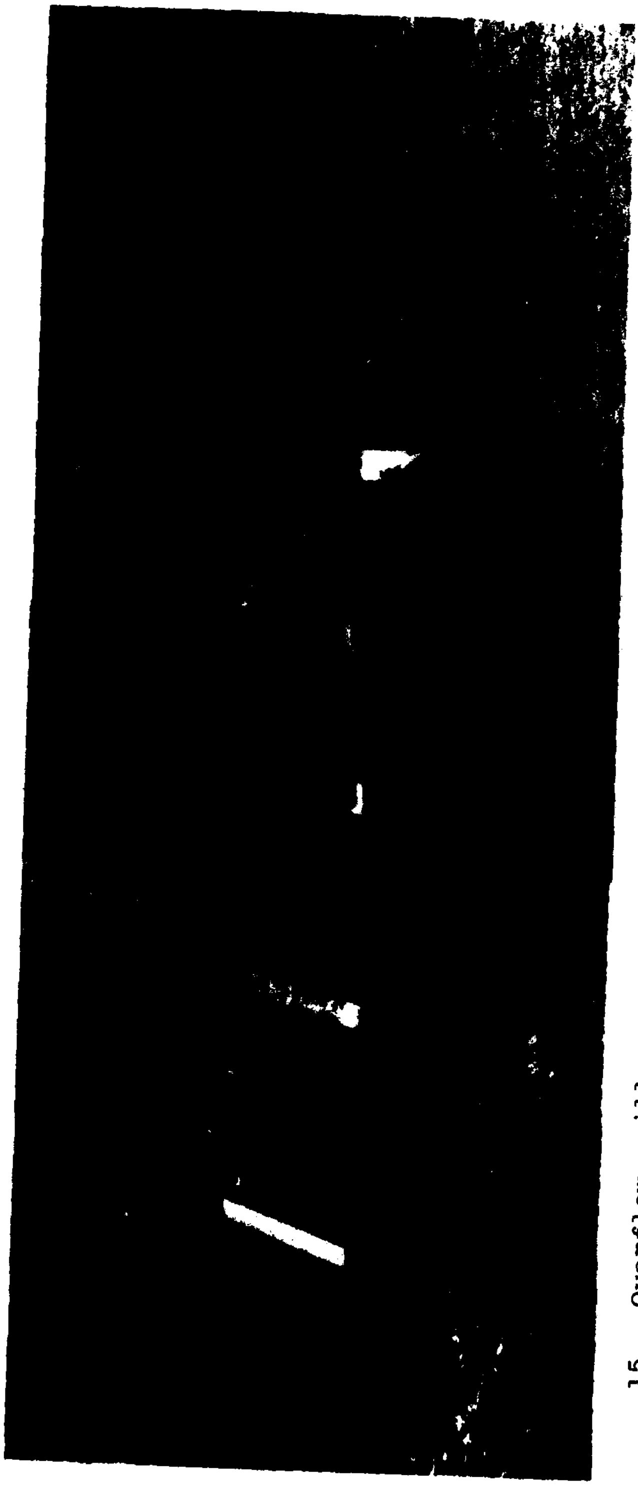


12. Downstream end of full stilling pool and channel to river

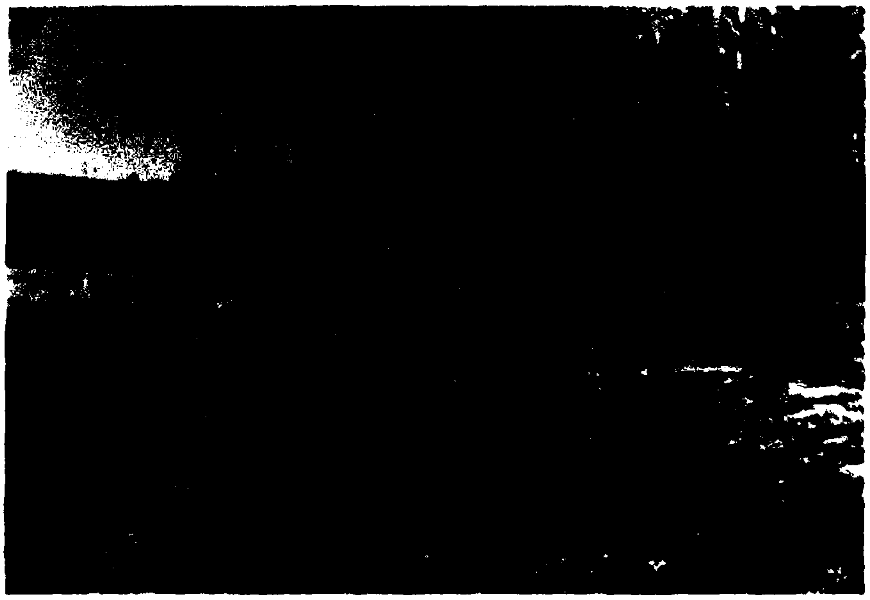
13. Stilling pool being drained



14. Seven foot diameter valves located beneath control house

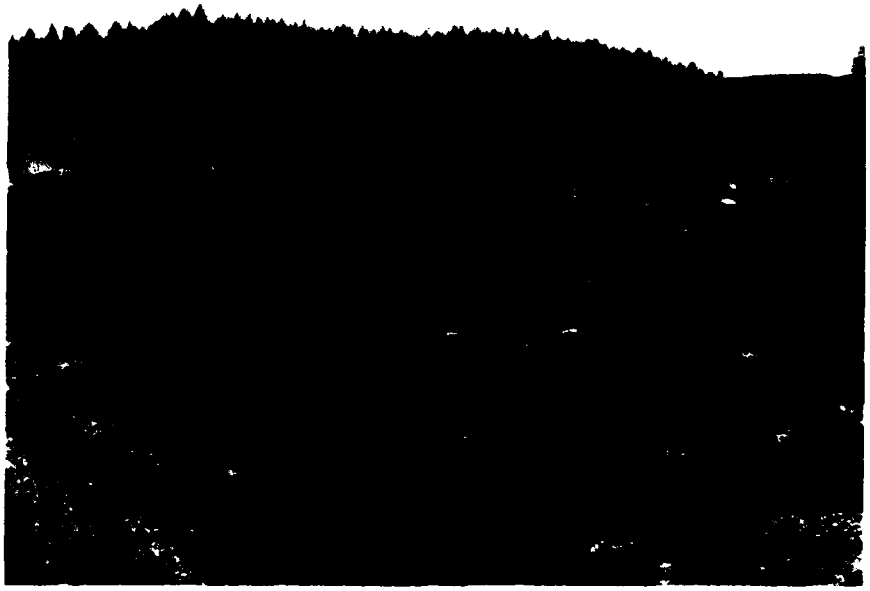


15. Overflow spillway



16. Downstream side of east spillway dike

17. Alignment of west spillway dike



18. Side approach channel from spillway walkway bridge

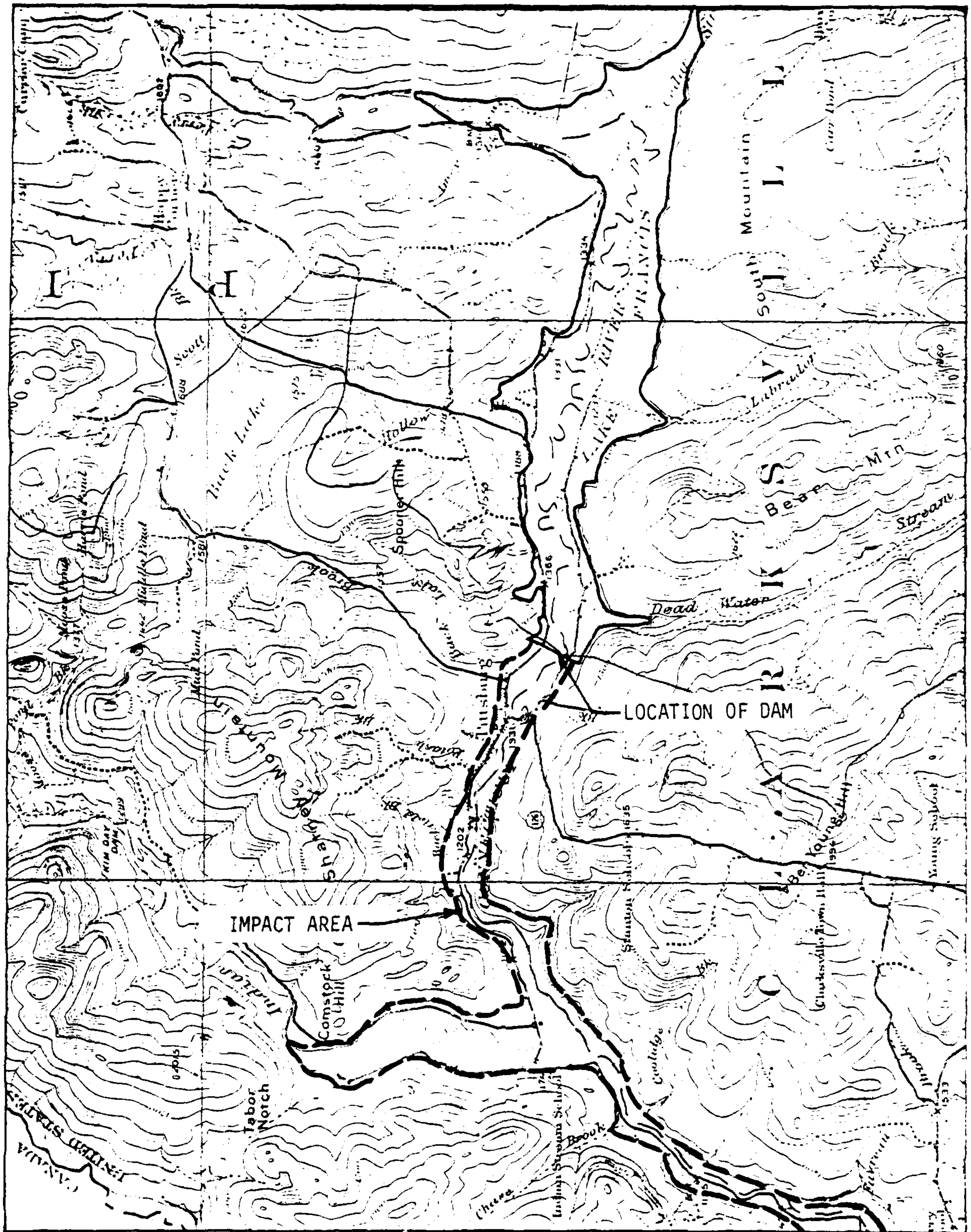
19. Spillway discharge channel and south spillway dike from spillway walkway bridge

20. Seepage condition at toe of spillway apron at the left wall

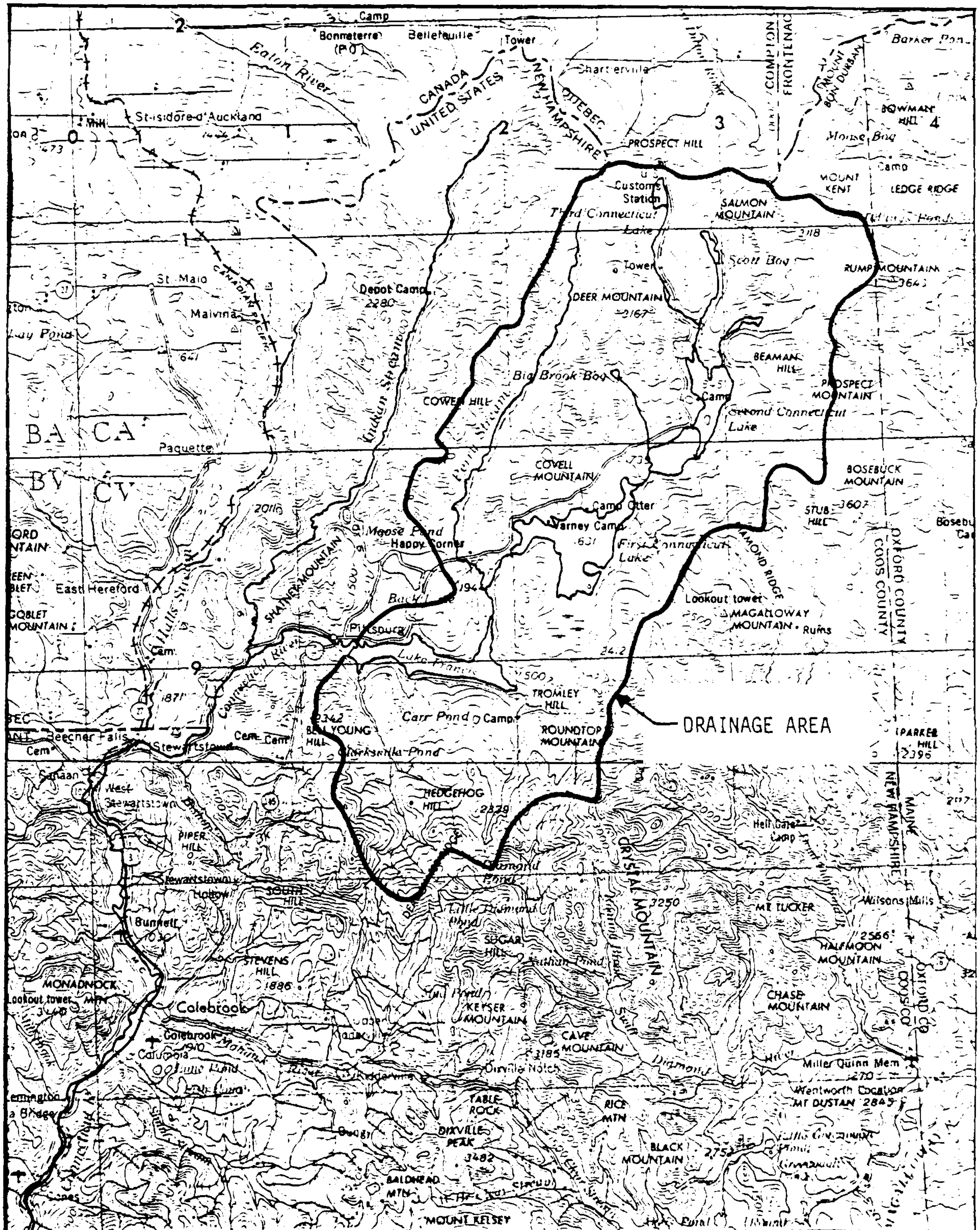
21. Cracks in panels of left spillway discharge channel wall

22. River channel and impact area immediately downstream of dam embankment

APPENDIX D - HYDRAULIC AND HYDROLOGIC COMPUTATIONS



MURPHY DAM NH 00185		DAM FAILURE IMPACT AREA MAP APPROX. SCALE: 1" = 5200'



MURPHY DAM NH 00185	DRAINAGE AREA MAP Approx. Scale: 1 inch = 4 miles

CAMP DRESSER & McKEE	CLIENT HALEY & ALDRICH	JOB NO. 561-10-RT-34	COMPUTED BY JED
	PROJECT PHASE I INSP	DATE CHECKED JRA	DATE 5/18/81
	DETAIL MURPY DAM	CHECKED BY June 5, 1981	PAGE NO 1 of

PROJECT FEATURES (Elev. datum - NGVD)

Top of Dam El. 1400.0
Toe of Dam El. 1294.0
Top of Spillway Dikes (East/West) El. 1400.0

Length of Dam = 2200 ft.

Spillway structure: total weir length = 224 ft. consisting of 5 bays with 4 ft. wide piers

Spillway Bay No.	Width (ft.)	Crest Elev.	Elev. of top of Boards
1	37	1370.0	1385.0
2	37	1375.0	1385.0
3	37	1375.0	1385.0
4	37	1375.0	1385.0
5	60	1383.0	1386.0

Surface Areas:
Project records give drainage area of 174 sq. mi. and reservoir surface area of 2,010 acres at El. 1385.0

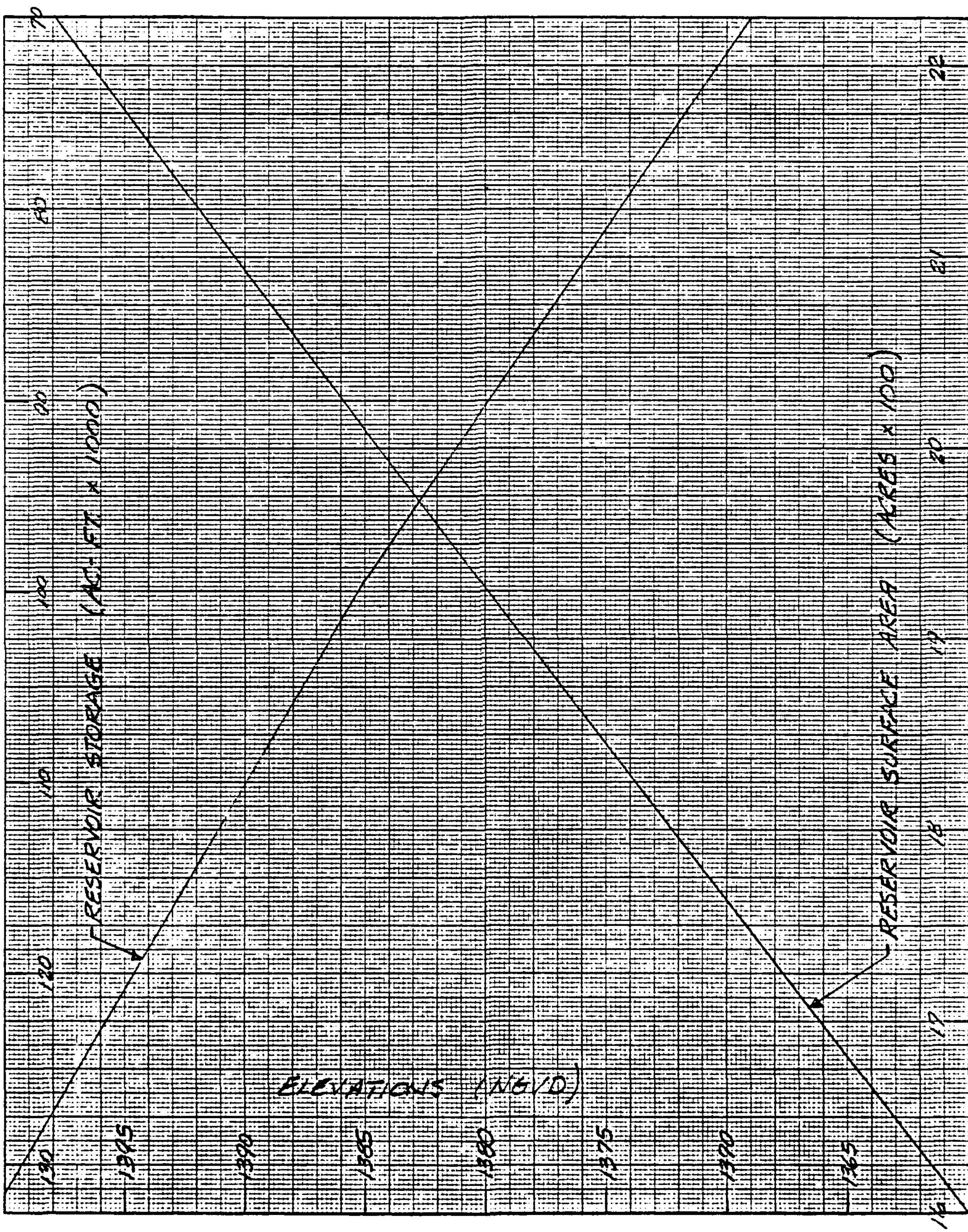
Planimetering of USGS Quad. at 1:62500 scale determined:

Elev.	Reservoir Area
1360.0	1600 acres
1400.0	2240 acres

Above is plotted on Surface Area - Reservoir Storage Curve, next page

Reservoir Volumes:
Project records give reservoir volume of 99,500 ac-ft. at El. 1385.0

Elev.	Surf. Area	Avg. Surf. Area	Incr. Storage	Total Storage (ac-ft.)
1360	1600 ac.			54,350
		1683 ac.	16,830 a-f	
1370	1766 ac.			71,180
		1888 ac	28,320 a-f	
1385	2010 ac.			99,500 ← given
		2125 ac.	31,875 a-f	
1400	2240 ac.			131,375


RESERVOIR STORAGE (AC-FT. x 1000)
RESERVOIR SURFACE AREA (ACRES x 100)
ELEVATIONS (NGVD)
1395
1390
1385
1380
1375
1370
1365
120
110
100
90
80
70
16
17
18
19
20
21
22

SIZE CLASSIFICATION

Height = El. 1400 - El. 1294.0 = 106 ft. > 100 ft.

Storage at top of dam (El. 1400.0) ≃ 131,375 ac-ft > 50,000

∴ Size is LARGE

DAM FAILURE ANALYSIS

Assume dam failure with reservoir at El. 1397.0 which is design high water for PMF.

$$Q_{P1} = 8/27\, W_b \sqrt{g}\, (H)^{3/2}$$

where W_b = 40% of mid-height length
= 0.4 × 1200' = 480 ft.
g = 32.2 fps/sec
H = El. 1397 - El. 1294 = 103 ft.

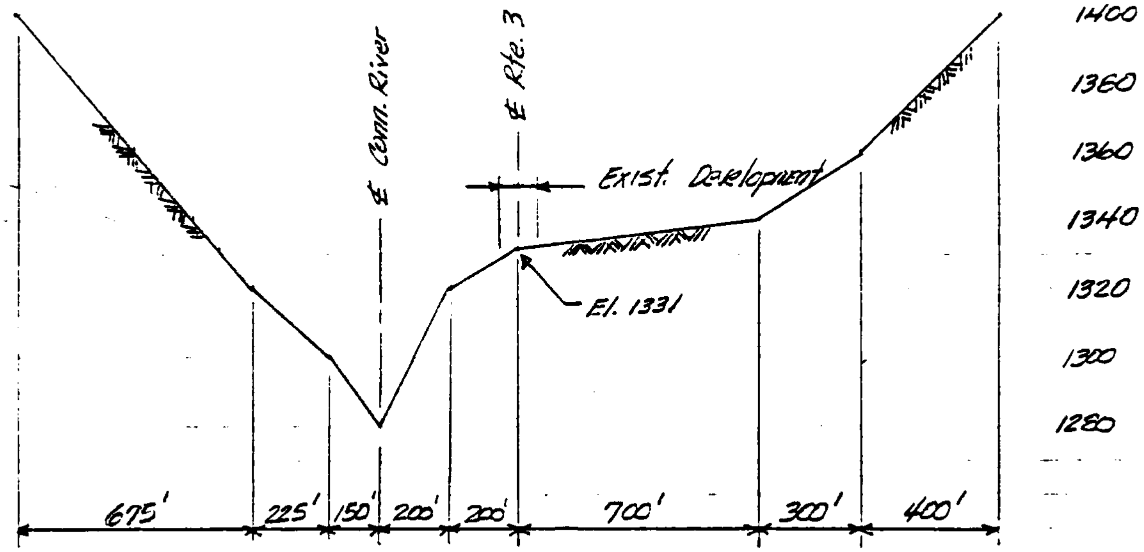
then $Q_{P1} = 8/27 \times 480 \times (32.2)^{1/2} (103)^{3/2} = 843{,}630$ cfs

Available downstream topography mapping consists of USGS Quads at a scale of 1:62500 or 1" ≃ 5200' with 20 ft. contour intervals dated 1926 and updated to 1946

The downstream channel consists of the Conn. River which flows past the Town of Pittsburg (located approx. 3000 ft. d/s of dam) and thence through a valley where the river is paralleled by Rte. 3. The Towns of Beecher Falls, VT, and Stewartstown, NH, are located approx. 9 miles d/s of the dam and the Towns of Canaan, VT, and West Stewartstown, NH, an additional 2 miles downstream. The Town of Colebrook, NH, is located approx. 20 miles d/s of the dam.

As minimal flood plain storage exists along the d/s channel relative to a peak failure outflow of > 800,000 cfs, extensive damage is likely to occur for several miles d/s of the dam.

Initial Impact on Town of Pittsburg :



CROSS SECTION ~ 3000 FT. D/S OF DAM

D/S channel $Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ where $n = 0.1$ for dam failure overbank flow
$S = 0.016$ from USGS Quad.

then $Q = 1.49/0.1 \; A R^{2/3} (0.016)^{1/2} = 1.885 \; A R^{2/3}$

ELEV.	AREA	R	Q (cfs)
1300	2500 $\boxed{1}$	10	21,900
1320	10,750 $\boxed{1}$	18.7	142,500
1331	18,725 $\boxed{1}$	21.4	272,100
1340	30,090 $\boxed{1}$	18.23	392,900
1360	67,840 $\boxed{1}$	31.92	1,286,800

By interpolation, the dam failure stage for Q_{P1} = 843,600 cfs would be ~ El. 1350

The approx. hydraulic slope between the dam and this section is then (1397-1350)/3000' = 0.0157 ≃ 0.016 ✓

The elevation of Rte. 3 through the Town of Pittsburg ~ 3000 ft. d/s of dam is El. 1331.0 Rte. 3 serves as main street through the town with residential and commercial development on both sides of the road. A dam failure stage of El. 1350 at this location would inundate most of the town by ~ 20 ft. of water. From the 1946 USGS Quad, a minimum of 30 structures would be impacted with the Town of Pittsburg.

With the exception of the floodplain at the confluence of Indian Stream with the Connecticut River, the d/s channel is located in a valley which is reasonably represented by the prior cross section. Since the dam failure is assumed to occur during a PMF, this floodplain would already be flooded and would not significantly attenuate the peak failure outflow. Consequently, flooding along the d/s channel would be expected to continue at a stage of about 50 to 70 ft. above the normal river water level for several miles d/s of the dam.

Consequently, the Hazard Classification is HIGH

PROJECT DISCHARGES

Normal reservoir operation is to release water via the 13 ft. dia. conduit upon demand by the d/s power generating facilities. Maximum normal reservoir level is El. 1378 or about 5 ft. below top of spillway boards. Conduit discharges are increased and water is wasted when the reservoir level approaches El. 1378 in order to maintain this level. Conduit discharges are regulated to a maximum of 2000 cfs.

During periods of high inflow, there are formal operating procedures to be followed by the operator in the event that communications with advisors is not possible.

A copy of the written procedures are contained in Appendix B and are summarized as follows:

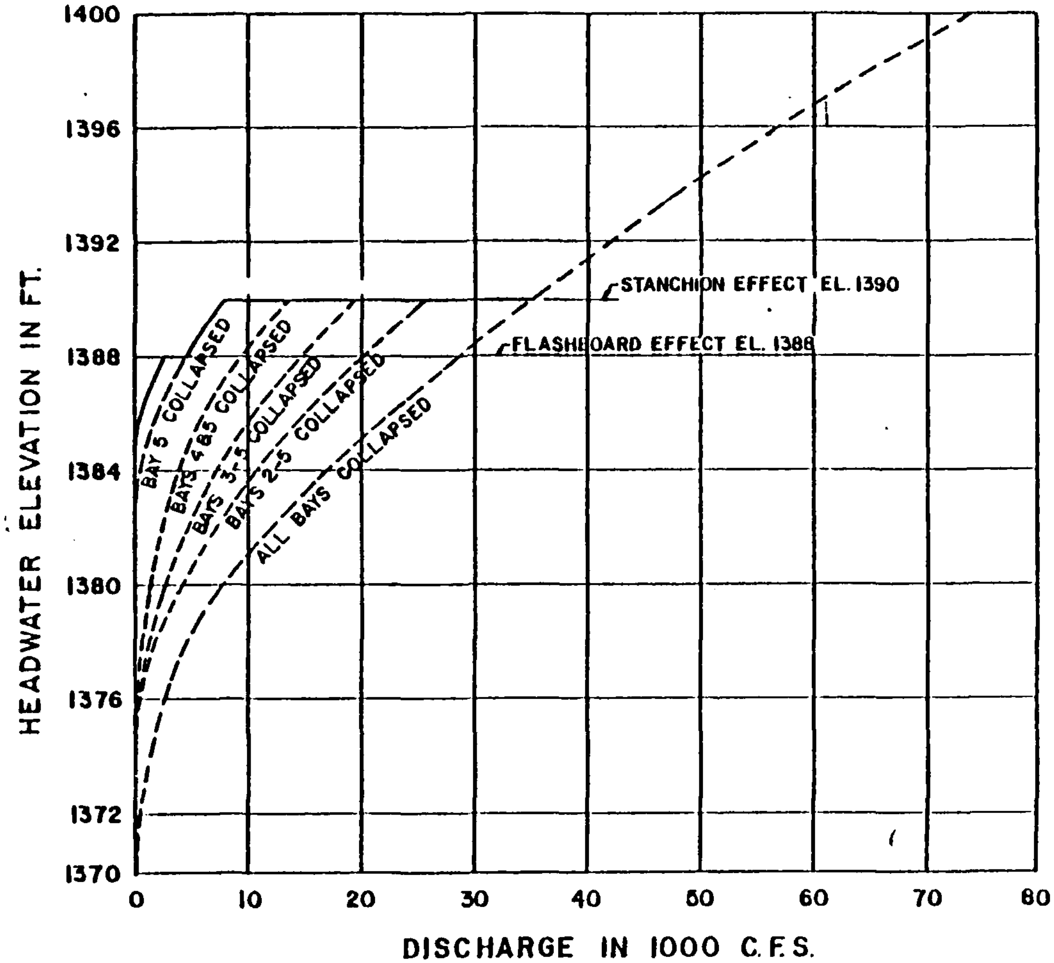
SPILLWAY OPERATING PROCEDURES

POND LEVEL	ACTION
<1385.0	Conduit discharges only
1385.0	Spillway discharge begins, close conduit control valves
1387.0	Open control valves to allow 100cfs discharge per 0.1 ft. rise above El. 1387.0
1387.6	Boards on half of Bay #5 fail, close control valves. If reservoir continues to rise, open valves to discharge 100 cfs/0.1' rise above El. 1387.6
1388.1	Boards on 2nd half of Bay #5 fail, close control valves.
1388.5	Open control valves to discharge maximum of 2000 cfs.
1389.0	Release stop logs on Bay #2, followed by Bays #3, #4, and finaly #1 as necessary to maintain level below El. 1390.0

Spillway discharges are a function of the operation of the flashboards and stanchions as outlined above. Following the release of all spillway boards, the following discharge capacities have been determined by the design eng'r:

Reservoir El.	Capacity (cfs)
1390.3	36,000
1397.0	61,000
1400.0	~74,000

Spillway rating curves reflecting the operation of the flashboards and stanchions have been developed by the design eng'r and are included on the next page.



NOTE

USE DASHED LINE CURVES AFTER FAILURE OF FLASHBOARDS & STANCHIONS.

NEW HAMPSHIRE WATER RESOURCES BOARD
Concord, New Hampshire
MURPHY DAM

SPILLWAY RATING CURVES

MAIN

DATE 23 AUG 1977

1318	11	D-1

TEST FLOOD DETERMINATION

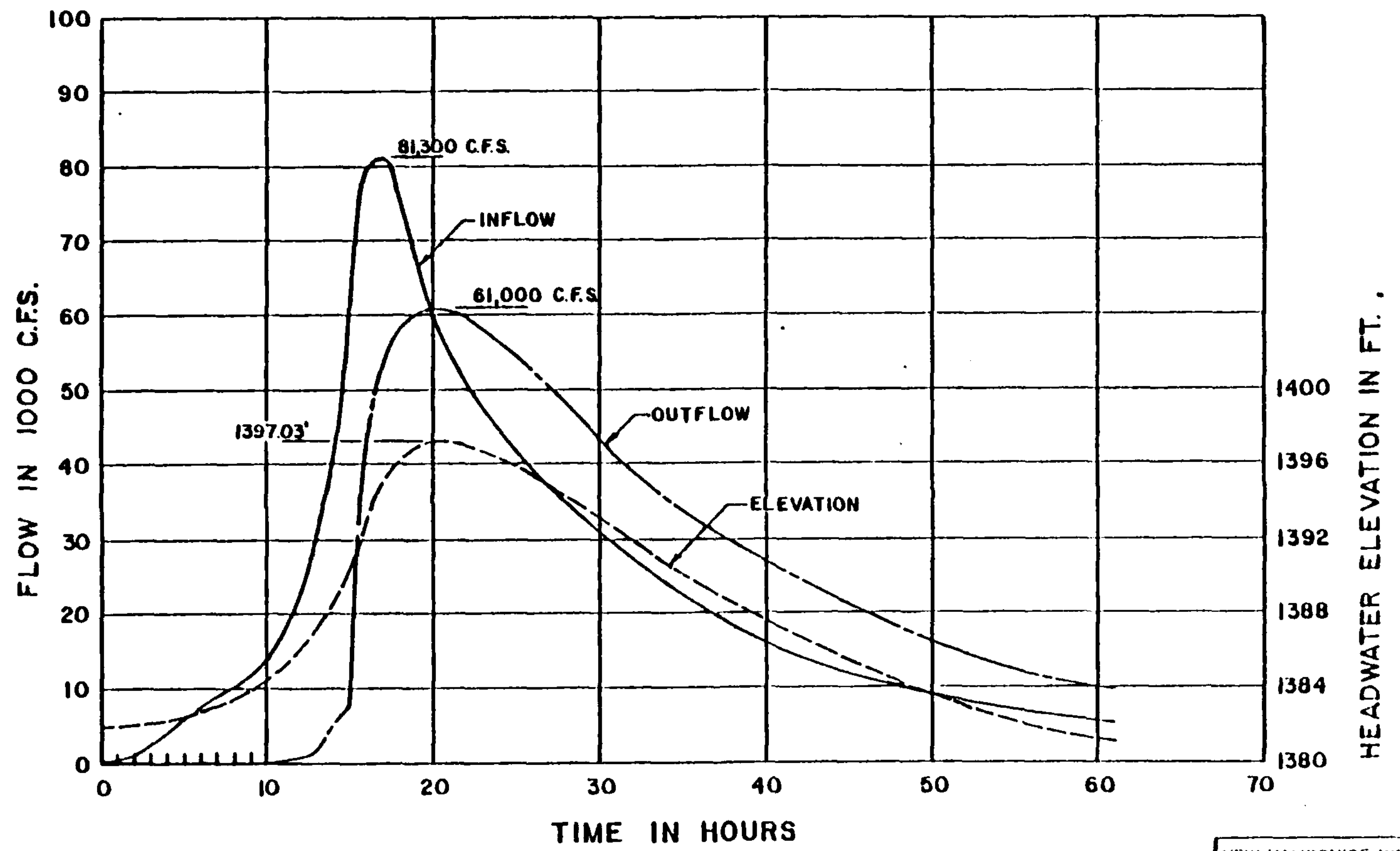
For a "large" dam having a "high" hazard, COE Guidelines recommend a test flood equal to the Probable Maximum Flood (PMF).

The 174 sq. mi. drainage area tributary to Murphy Dam consists of two tributary watersheds - Perry Stream having 78 sq. mi. of uncontrolled D.A. and 96 sq. mi. which is controlled by the First, Second, and Third Connecticut Lakes. Because of the attenuating effects of the Connecticut Lakes, application of the COE Guidelines Curves for estimating peak PMF inflows is inappropriate.

PMF analysis was performed in 1977 by the design engineer, C.T. Main. Unit hydrographs were developed based on a geomorphologically similar watershed. The USGS gage on the Ammonoosuc River at Bethlehem Junction, NH was selected for this purpose. The PMF outflow from the First Conn. Lake was determined to be 34,200 cfs (inflow = 53,690 cfs) which, when combined with the Perry Stream PMF hydrograph, resulted in a Lake Francis inflow of 81,300 cfs.

The Lake Francis routed PMF outflow peak was determined to be 61,000 cfs at a reservoir stage of El. 1397.0. At this stage, the spillway concrete structures would be overtopped by about 4 ft. However, there would be 3 ft. of freeboard on the dam embankment and the spillway east and west dikes which are at El. 1400. Consequently, it was determined that flooding would be limited to the spillway discharge channel including the d/s spillway channel bridge and farm buildings in the immediate area.

The published PMF hydrographs together with a summary of the PMF analysis is included on the following pages.



NEW HAMPSHIRE WATER RESOURCES BOARD
Concord, New Hampshire
MURPHY DAM
HYDROGRAPHS
PROBABLE MAXIMUM FLOOD ROUTING

MAIN

DATE 23 AUG 1977

1318 11 D-11

9/

The total catchment commanded by Murphy Dam, 174 sq. mi., is drained by two major tributaries, the Connecticut River and Perry Stream. The Connecticut River flows from the Third Lake through the Second Lake and First Lake to its confluence with the other major tributary, Perry Stream, and thence into Lake Francis.

This natural diversion of the catchment into two major sub-basins mandated the derivation of unit hydrographs and the development of Probable Maximum Floods for each.

The two USGS gages extant in the project locus at First Connecticut Lake near Pittsburg, NH, and below Perry Stream, near Pittsburg, NH, are both affected by upstream storage and consequently could not be used for the derivation of unit hydrographs. A search of the general area disclosed a USGS gage on the Ammonoosuc River at Bethlehem Junction, NH, that was not impacted by major storage and drained an area geomorphologically similar to the subject catchment. This gage commanded an area of 87.6. sq. mi. and had a period of record extending back to 1940.

In the search for a gaged basin from which to derive a characteristic unit hydrograph, the geomorphological aspects were taken into consideration. The circularity, R_c ratios (the ratio of the basin area to the area of a circle having the same circumference of the basin) were computed as well as the elongation ratio; R_e (the ratio of the basin area to the area of a circle with a diameter equal to the maximum basin length).

Both of these indicators are shown below:

Basin	R_c	R_e
Perry Stream	0.34	0.7
Connecticut R.	0.50	1.0
Ammonoosuc R.	0.43	0.6

These indicators are well within the accepted limits for morphological similitude.

From the above data base, two non-snowmelt flood events: June, 1973 and October 1959, were selected for analyses. Thiessen polygons were constructed, the rainfall distribution over the basin was determined for each storm and the unit hydrograph for each storm developed. As the unit hydrograph derived from the October, 1959 flood event had the highest peak and the shortest lag time, it was adapted to each sub-basin in the subject catchment on a square mile of drainage area basis.

The Probable Maximum Precipitation values were taken from the joint US Corps of Engineers-US Weather Bureau "Hydrometorology Report #33" for the combined drainage area of 174 sq. mi. In order to obtain a distribution of these Probable Maximum Precipitation (PMP) values over the sub-basins for application to the unit hydrographs, a typical isohyetal pattern was assumed. The pattern was centered on the Lake Francis subarea (78 sq. mi.) and the Hydromet. #33 values, after a trajectory adjustment, for 78 sq. mi. were utilized. The PMP increments for the 96 sq. mi. tributary to First Connecticut Lake would be the interval differences between the values for the 78 sq. mi. sub-basin and PMP values for the total catchment 174 sq. mi. Table 1 below shows the ordered hourly PMP and rainfall excess values for the 78 sq. mi. and 96 sq. mi. subareas.

Hour	78 sq. mi. PMP	78 sq. mi. Excess	96 sq. mi. PMP	96 sq. mi. Excess
1	0.4"	---	0.3"	---
2	0.6"	0.5"	0.7"	0.6"
3	1.1"	1.0"	1.1"	1.0"
4	8.6"	8.5"	6.2"	6.1"
5	0.7"	0.6"	0.8"	0.7"
6	0.4"	0.3"	0.7"	0.6"
*7	0.3"	0.3"	0.4"	0.4"
8	0.3"	0.3"	0.4"	0.4"
9	0.3"	0.3"	0.3"	0.3"
10	0.2"	0.2"	0.3"	0.3"
11	0.2"	0.2"	0.3"	0.3"
12	0.2"	0.2"	0.2"	0.2"
SUM.	13.3"	12.4"	11.7"	10.9"

* Losses assumed at 0.1"/Hr. to the 7th Hr. with no losses thereafter.

These hourly rainfall excess increments for each subarea were then applied to the appropriate unit hydrograph ordinates to produce the inflow hydrographs.

In the case of the main stem Connecticut, an appropriate base flow was added and the combined inflow routed through the First Connecticut Lake storage with a peak inflow of 53,690 cfs., a peak outflow of 34,200 cfs. and a maximum reservoir elevation of 1634.9 ft.

In the case of Lake Francis, an elevation-duration curve for the 31st. of August was prepared and that elevation which was found to be equalled or exceeded only 10 percent of the time, 1382 ft., was selected. Combining the Perry Stream Probable Maximum Flood (PMF) with an appropriate base flow and with the routed PMF outflow from First Connecticut Lake gave a PMF inflow hydrograph to Lake Francis. This flood hydrograph was then routed through the Lake Francis storage. see Plate D-II. The peak inflow was 81,300 cfs., the peak outflow equalled 61,000 cfs., and the maximum lake elevation of 1397 ft. Since this flood transitted the reservoir with a

freeboard of 3.0 ft., no further consideration of overtopping was given.

It is MAIN's customary procedure to do a standard return period analysis for any USGS gages with appropriate periods of records that are in the project basin or similar basins. In this case the USGS Regional Flood Frequency methodology was utilized and the extrapolated 1000 year floods for First Connecticut Lake was found to be 26,500 cfs., and the extrapolated Perry Stream peak was computed at 39,000 cfs. It must be pointed out that the particular upstream storage peculiar to this catchment is not reflected in this regional flood method.

As an additional order of magnitude check, the Creager C was computed for First Connecticut Lake as 44.8 and for Perry Stream above the confluence was 51.7.

CAMP DRESSER & McKEE CLIENT HALEY & ALDRICH JOB NO. 80-IC-KT-34 COMPUTED BY ED
PROJECT PHASE I INSP. DATE CHECKED 6-5-81 DATE 5/26/81
DETAIL MURPHY DAM CHECKED BY SRA PAGE NO 14 of

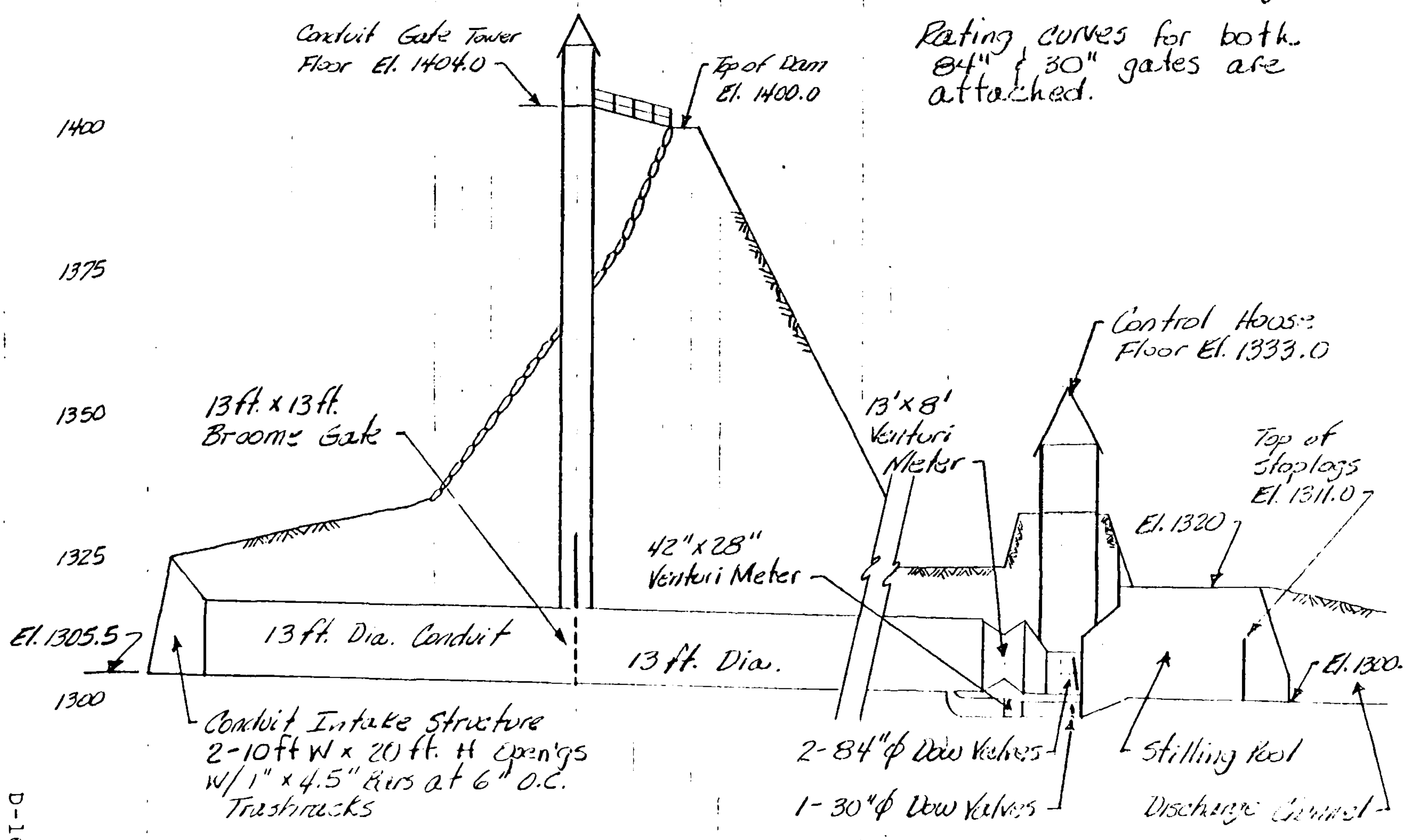
OUTLET WORKS - Profile of Conduit & Controls

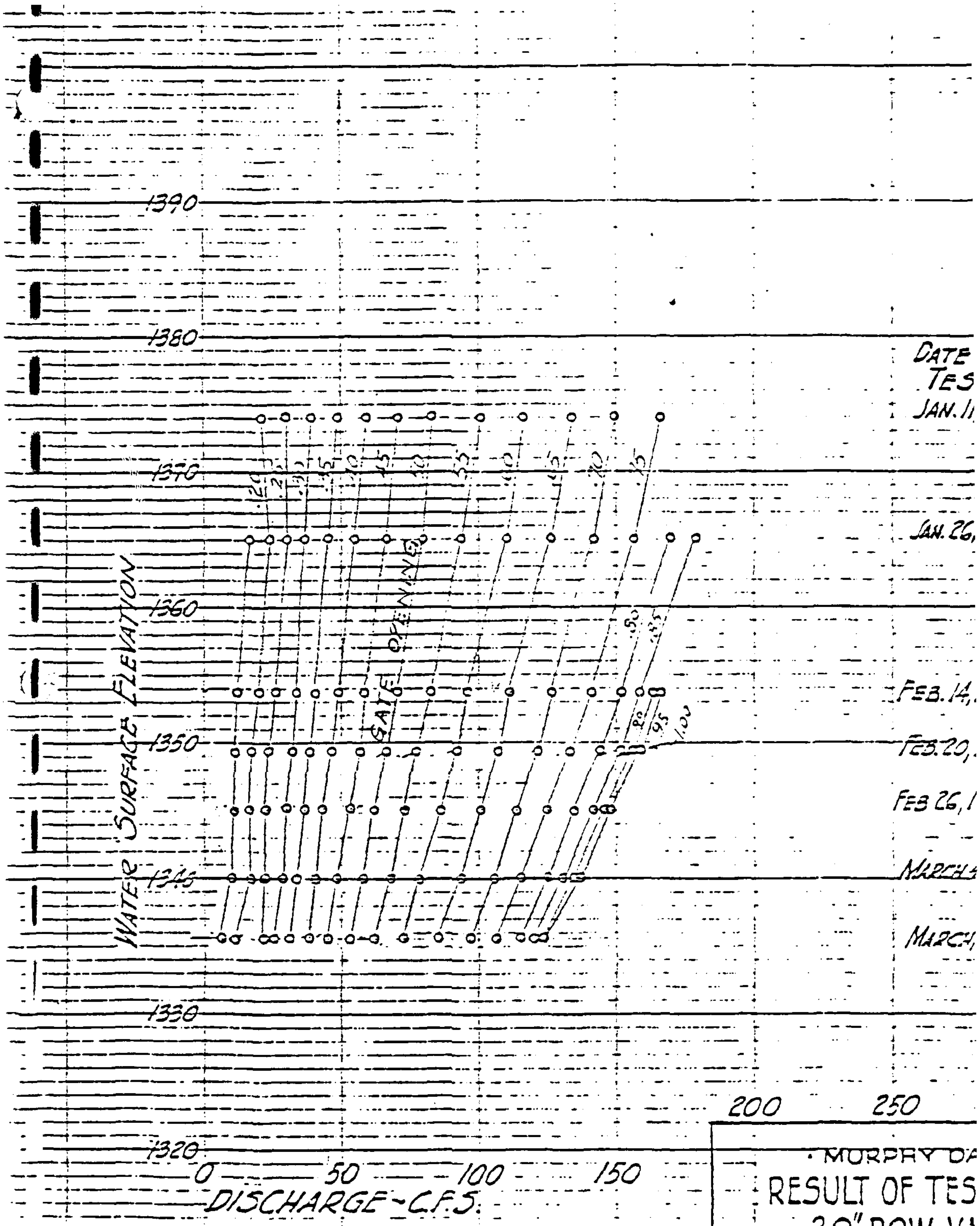
Notes:

Overall 13 ft. conduit length: 975 ft.

Estimated max. discharge: 2000 cfs

Rating curves for both 84" & 30" gates are attached.





· MURPHY DA

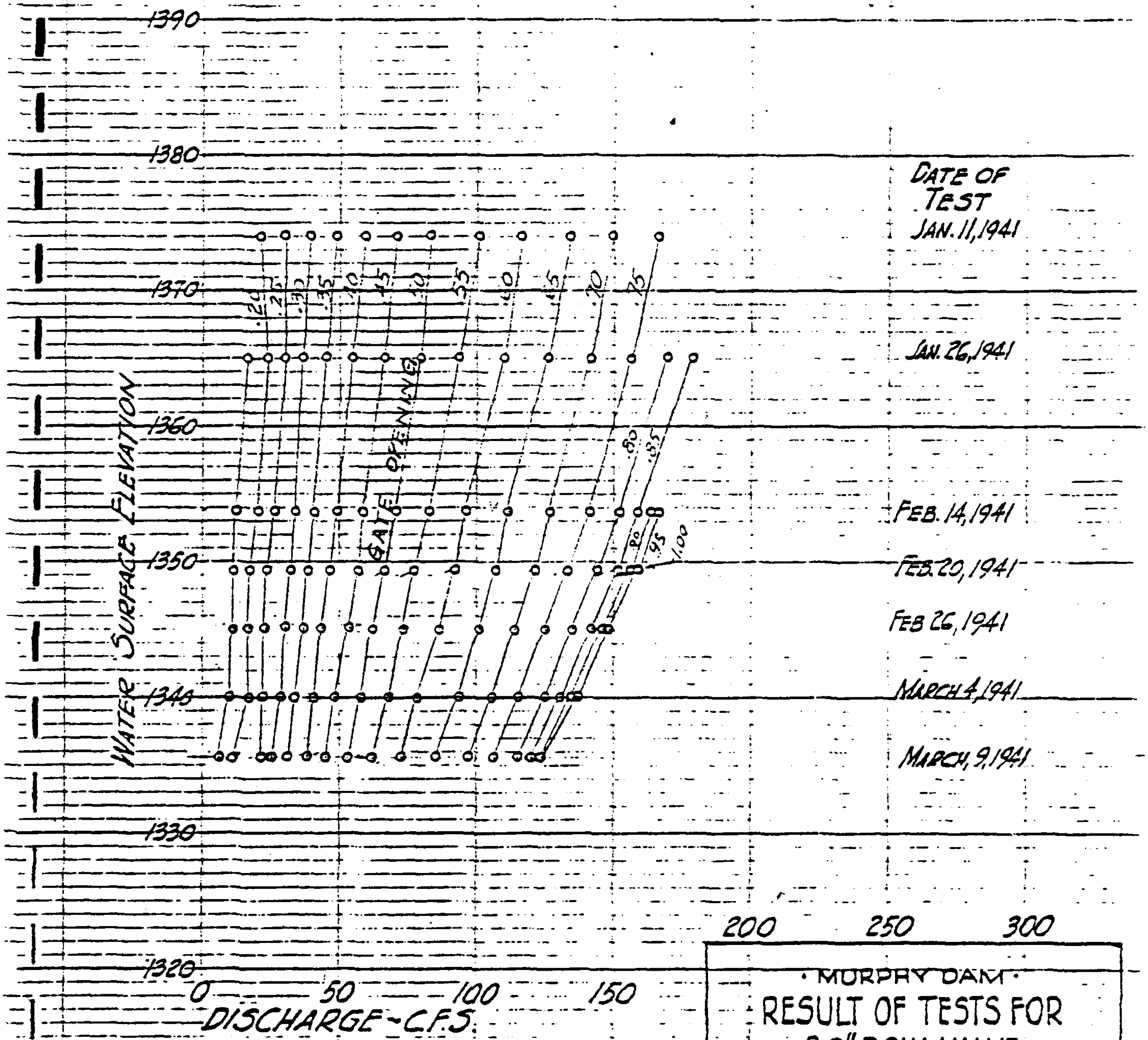
RESULT OF TES

30" DOW VA

No. 3

NEW HAMPS

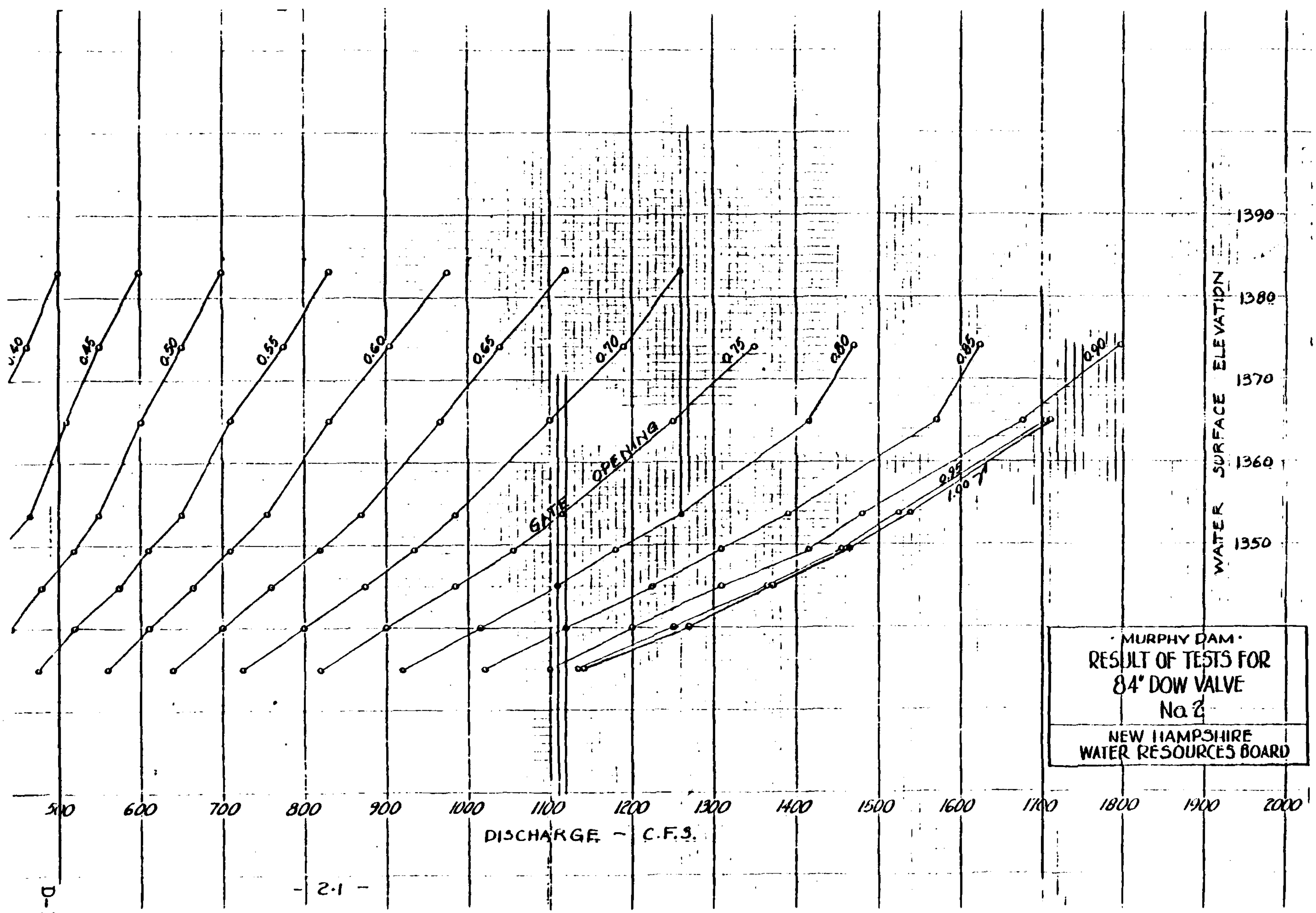
WATER RESOURC



· MURPHY DAM ·

RESULT OF TESTS FOR 30" DOW VALVE No. 3

NEW HAMPSHIRE WATER RESOURCES BOARD


· MURPHY DAM ·
RESULT OF TESTS FOR
84" DOW VALVE
No. 2
NEW HAMPSHIRE
WATER RESOURCES BOARD
WATER SURFACE ELEVATION
1390
1380
1370
1360
1350
DISCHARGE ~ C.F.S.
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
GATE OPENING
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00

APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

ATE

LMED

-8

ATE

LMED

-8